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SUBJECT Work on the Chemistry of Collagen and Connective Tissue

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1. The chemistry of connective tissue is of considerable interest to military medicine. During World War II when natural gut was not available in sufficient quantity to meet the demand, satisfactory sutures were produced from reconstituted collagen. Tubular collagen was successfully used to connect severed nerve ends, and pieces of collagen in various shapes were used in serious wound operations. By varying the amount of tanning to which the collagen was subjected, the degree and speed at which the material is absorbed by the body could be controlled.

2. In the period 1947-1950 a group of Soviet biochemists did some very interesting basic work on the chemistry of collagenous tissue;

S. Y. Bresler
M. P. Chernikov
N. N. Dobbert
P. A. Finogenov
(S. Y.?) Frenkel
A. S. Konikova
V. N. Orekhovich
K. D. Orekhovich
N. Ye. Plotnikova
A. D. Speranskiy
A. A. Tustanovskiy

have published papers on the subject. In general these men performed experiments in which they extracted collagen from animal tissue by means of acidic buffers. After getting the collagen in solution they reconstituted the collagen as synthetic fiber. They were primarily interested in the chemistry of the substance, its distribution in animal tissue, and its connection to the precursor of animal cells. Results of their work were published by the Academy of Medical Sciences in the journal "Biochimia" and elsewhere, including the following:

Chernikov, M. P. "Amino Acid Content of Ox Procollagen". Doklady Akad. Nauk, U.S.S.R. 67, 345-7, 1949.
"The Amino Acid Properties of Bovine Procollagen". Reports of the Academy of Sciences of the USSR, LXVII, 2, p. 345-9.
Orekhovich, K. D. "The Procollagen Content of Skin in Animals of Different Ages". Akademiia Nauk USSR Doklady, 71:521, 1950.
"The Procollagen of Hide". Biokhimiya 13 (1), 55-60, 1948.

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Orekhovich, V. N., Konikova, A. S., Orekhovich, K. D., and Dobbert, N. N. "Concerning the Metabolic Turnover Rates of Various Organ and Tissue Proteins". Akademiia Nauk USSR Doklady, 71:105, 1950.

Bresler, S. Y., Finogenov, P. A., and Frenkel, S. Y. "A discussion of the structure of the Macromolecule of Procollagen". Reports of the Academy of Sciences of the U.S.S.R., LXXII (72), 3, pp. 555-8, 1950.

Tustanovskiy, A. A. "Concerning the Proteins of Skin". Biokhimiia, 12 (4): 285-290, 1947.

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3. Two other Soviets, S. L. Pupko and A. L. Zaydes have also written on electron-microscopic investigations of collagen published in proceedings of the Academy of Sciences:

Zaydes, A. L. and Pupko, S. L. "Electron-Microscopic Investigation of the Effects of Alkalis and Pancreatin on Collagen". Akademiia Nauk USSR Doklady, Vol. 73: 991, 1950.

"The Electron-Microscopic Examination of Collagen". Reports of the Acad. of Sci. of USSR, LXV, 2, pp. 227-8, 1949.

"The Electron-Microscopic Examination of Collagen Using the Replica Technique". Akademiia Nauk USSR Doklady, Vol. 73: 379, 1950.

25X1A [redacted]

The fact that they are members of the Central Research Institute of the Leather Footwear Industriss leaves little doubt as to the Soviet belief in the future of reconstituted collagen.

4. US scientists reviewing this work found the Soviet conclusions particularly interesting. For the past three years [49-52] a group of US scientists has been working on the ultrastructure of connective tissue based on the work of the above named Soviet scientists. The US group also hopes to gain information on the formation and nature of collagen and determine its molecular structure. To date attempts of US scientists to make contact, through the Soviet Academy of Science, with the Soviet collagen specialists have been unsuccessful. The Soviets also have never mentioned US work in the field; so it is hard to assay Soviet progress.

5. In these days of the successful use of such agents as cortisone, many people are getting on the bandwagon to investigate connective tissue, and the field is becoming increasingly more popular. Results of this research will find application in medicine and may give insight into such phenomena as wound healing and aging. The production of synthetic fiber and synthetic leather as a result of this research is quite possible.

25X1 [redacted]

8. This side of the Iron Curtain, the British are probably the leaders in the field. Germany and Scandinavia are also very active in tissue ultrastructure. There seems to be some work going on in Italy. [redacted]

25X1 [redacted]

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- end -

Bresler, S.Y., P. A. Finogenov, and S.Y. Frenkel. A discussion of the structure of the Macromolecule of procollagen. Reports of the Academy of Sciences of the U.S.S.R., LXXII (72),3, pp. 555-8, 1950.

In 1947 V. N. Orekhovich and A. A. Tustanovsky (1) isolated a new crystalline albumin from the skins of animals, which they called procollagen, and studied its properties in detail (2-8). Aside from the purely biological problems which arose because of this discovery, the new albumin presented much interest from the standpoint of the physical-chemistry of macromolecules. By all external appearances it was similar to fibrous albumins, since, for instance, it gave a solution with high viscosity. On the other hand, a strong tendency to form crystals made it comparable to the globular albumins.

1. We investigated the procollagen from the skin of rats. The sedimentation constant S of the albumin was measured in the ultracentrifuge in concentrations of 0.045 to 0.45%. We also found the diffusion constant D at several concentrations, the specific volume and the viscosity. The experiments in the ultracentrifuge were carried on at 60,000 RPM, giving an acceleration of 250,000 g., and the sedimentation velocity was followed by the scale method of Lamma. The diffusion measurements were made on an apparatus provided with automatic recording devices over the period of two to three days.

For every experiment a fresh solution of procollagen was prepared in 0.025 citrate buffer at a pH of 3.0 (this pH is the most stable one for albumin). Afterwards the solution was filtered to remove a small amount of flocculent precipitate, using a No. 4 glass filter, upon which it appeared perfectly transparent. The percentage of procollagen was determined from the nitrogen content.

2. The first thorough investigation by us of the properties of procollagen disclosed that if it did not become denatured, this protein was really a monodisperse albumin, and therefore that it really belonged to the group of globular proteins. Fig. 1 shows the sedimentation of procollagen in the ultracentrifuge (albumin conc. of 0.2%). In Fig. 2 is presented the variation of the sedimentation constant S, normalized as usual to 20° C. and pure water, as a function of the concentration of the albumin. The increase of the sedimentation constant with a decrease in concentration is explained by the fact that large elongate molecules do not move independently of each other in concentrated solutions.

The measurement of the diffusion constant of procollagen presents certain difficulties, for when the albumin is maintained for some time at 25° C. it starts to denature and coagulate. Nevertheless, under high enough concentrations (above 0.3%) the error caused by this deformation is negligibly small and allows the calculation of the coefficient of diffusion with gratifying accuracy. In the concentration interval between 0.3 and 0.5% the diffusion constant has an average value of $2.2_4 \times 10^{-7}$ cm^2/sec. (adjusted also to pure water and 20° C.). One can assume that an average value of D occurs at the center of the interval, i.e. at 0.4%.

With S and D known it is possible to calculate the molecular weight of the procollagen by the formula of Svedberg:

$$M = \frac{S}{D} \frac{RT}{1 - \bar{v}\rho}$$

(1)

Here S is the sedimentation constant, i.e. the velocity of the macromolecules divided by the acceleration; M is the molecular weight; $\bar{v}$ is the specific volume;

ρ is the density of water at 20° C. (.9982); D is the diffusion constant; T the absolute temperature (293° K.); and R the universal gas constant ($8.313 \cdot 10^7$ erg/degrees).

The specific volume was measured using a pycnometer and turned out (at 20°C) V = 0.720 ±0.005.

By using the value at 0.4% conc. from Figure 2, S = (1.8 ±0.05) x 10^{-13} one obtains for the molecular weight of procollagen M = 70,000 ±3500. This allows one to compare procollagen to the large group of globular albumins near the weight of 70,000, which corresponds to four of the elementary units of Svedberg (17,500).

3. Now we consider the degree of asymmetry of the albumin. For this purpose we use the value of S extrapolated back to zero concentration of albumin, i.e. $S = 3 \cdot 10^{-13}$ (Fig. 2). From the formula of sedimentation:

$$S = \frac{M(1-\rho V)}{f} \qquad (2)$$

we find the frictional force f. This frictional force is related to the movement of the macromolecules in an infinitely dilute solution, i.e. when it does not depend on their interaction. If the macromolecules are spheres one can apply Stokes law $f_0 = 6\pi\eta a$, where $a = \sqrt[3]{\frac{3}{4\pi}\frac{MV}{N}}$ - radius of the sphere (N is Avogadro's number).

For this case we make use of the empirically found relationship:

$$\frac{f}{f_0} = 1.19 \times 10^{-15} \frac{M^{2/3}(1-V\rho)}{SV^{1/3}} \qquad (3)$$

If this equation (and it is exactly of the same magnitude as observed by Svedberg for the most asymmetric globular albumins) is completely

explained by the asymmetry of the sphere it can be used to relate the formula for frictional forces to the dimensions of a prolate ellipsoid:

$$\frac{f}{f_0} = \frac{\sqrt{1-\lambda^2}}{\lambda^{2/3} \ln \frac{1+\sqrt{1-\lambda^2}}{\lambda}} \qquad (4)$$

Using our data the ratio of two semi-axes becomes:

$$\lambda = \frac{b}{a} = \frac{1}{23}$$

Consequently, the molecule of procollagen presents a cylinder with a length about 20 times its maximum diameter. Knowing the volume of the molecule $v = \frac{MV}{N}$, we find that the diameter d = 16.7 Å, and the length L = 380 Å.

Since the approximate amino acid composition of the macromolecule is known (8) we can calculate the average molecular weight of the residues, m = 117, and therefore the degree of polymerization of the procollagen $\nu = \frac{M}{m} \approx 600$. As the length of a single peptide bond equals about 4 Å, the length of the whole polypeptide chain in procollagen must be 2400 Å, that is 6.25 times the length of the length L of the macromolecule. This undoubtedly means that the polypeptide chain is coiled in the macromolecule of the albumin.

4. In conclusion we will discuss the morphological reactions of a solution of procollagen under the action of salts. It was known that the presence of salt directly affects a solution of procollagen, changing, in particular, its viscosity. We examined in the ultracentrifuge a solution of procollagen in 0.32 M NaCl at a pH of 3.0.

The result was that next to the original peak of the procollagen appeared two new peaks, having a somewhat higher sedimentation rate (Fig. 3). This indicated the appearance of "dimers" because of the association of globules. Evidently this association can take place by different paths. The simplest variation of this association consists in the elongation of the globule by

two (association in length). Using formulas (2) and (3) easily shows what will happen in this case.

Equation (3) may be written as

$$\left(\frac{f}{f_0}\right)_1 = \frac{\text{const}\ M^{2/3}}{S_1}$$

For the dimer we have the corresponding

$$\left(\frac{f}{f_0}\right)_2 = \frac{\text{const}\ (2M)^{2/3}}{S_2}$$

Therefore

$$\frac{S_2}{S_1} = 2^{2/3}\left(\frac{f}{f_0}\right)_1 \Big/ \left(\frac{f}{f_0}\right)_2 \qquad (5)$$

In our case of linear association $\left(\frac{f}{f_0}\right)_2 = 2.78$ (the length of the cylinder is doubled while the radius remains constant). This would give theoretically $\frac{S_2}{S_1} = 1.21$. In actuality we obtained $S_2 = 3.083 \times 10^{-13}$, $S = 2.558 \times 10^{-13}$, and therefore $S_2/S_1 = 1.20$, which constitutes an ideal correlation.

Definitely interesting is the second peak, a sedimentation with the values of $S_3 = 3.91 \times 10^{-13}$, $S_3/S_1 = 1.53$, which is almost equal to $2^{2/3}$ (1.59). This corresponds to an association of the two macromolecules along the length of the sides of a forming cylinder. In this case the semi-minor axis of the ellipsoid, as the length, stays constant, and the relation f/f_0 of the dimers is approximately equal to that of ordinary molecules.

This experiment demonstrates that under the action of salts, as is known, the ionic attraction between primary groups of the albumin is decreased (at a pH of 3.0 the dissociation of the acid groups is mainly supressed). We also see that molecules of procollagen combine in pairs, forming two types of dimers - linear and lateral.

BIBLIOGRAPHY

1. Orekhovich, V.N., A.A. Tustanovsky, and K.D. Orekhovich: Reports of the Academy of Sciences, 57, pp. 475 (1947).

2. Orekhovich, V.N.: Chemical Proceedings, (?), 26, pp. 630, (1947).

3. Tustanovsky, A.A.: Biochemia, 12, pp. 285, (1947).

4. Plotnekova, N.E.: R.A.S., 58, pp. 1715, (1947).

5. Orekhovich, V.N. et al: Biochemia, 13, pp. 55, (1948).

6. Orekhovich, V.N. et al: R.A.S., 60, pp. 837, (1948).

7. Plotnekova, N.E.: R.A.S., 66, pp. 114, (1949).

8. Chernkov, M.P.: R.A.S., 67, No. 2, (1949).

Translated by Walter R. Stahl
November 20, 1950

Chernikov, M. P. Amino acid content of ox procollagen. Doklady Akad. Nauk. U.S.S.R. 67, 345-7, 1949. (Presented by the Academician A. D. Speransky, May 5, 1949).

For the past three years U. N. Orekhovich and his collaborators have been conducting a thorough study of the procollagen (1-12) of proteins which were isolated in the laboratory in crystalline form from the skin and internal organs of humans and various animals.

Along with the study of the biological and physical chemical properties and the investigation of the prevalence of protein in the tissues of various animals (13,14) work was also conducted in the investigation of the qualitative (N. E. Plotnikov) and quantitative amino acid composition of the given protein. Some of the results of the chemical investigation of procollagen are set forth in this paper.

The procollagen was obtained from the hide of an ox immediately after skinning. The hide was washed, shaved, the fat and cellular tissues carefully removed, after which the hide was washed again in a current of running water and was ground in a meat chopper after having been cut up into small pieces. The resulting paste was used for the isolation of protein, globulin and procollagen.

After extracting the albumen and globulin with 1/15 M Na_2PO_4 the paste was washed with a citrate buffer, pH = 3.5.

The procollagen was extracted with a triple quantity of citrate buffer in the course of 3-4 days at a temperature of +2°. Thymol and toluene were used in all cases for preservation.

The amorphous preparation of procollagen was obtained from the citrate extract by saturating it with dry NaCl up to 10%. The precipitate of albumen settled in the form of white flakes which were collected on the filter. To cleanse the procollagen from concomitant albumen, it was washed on the filter many times with a 5% solution of NaCl. To remove salts the procollagen was made turbid in a 15-20% solution of acetone with a subsequent centrifuging.

This operation was repeated to a negative reaction for chloride ions and a negative Millon's reaction, since the absence of tyrosine indicates the purity of procollagen compounds. Beyond that the protein was dried by the regular method with acetone and ether.

The resulting compound of the ox procollagen contained 0.47% ash, 17% nitrogen, 49% carbon and 7% hydrogen.

To determine tryptophane, tyrosine and phenylalanine, an alkaline hydrolysis was carried out with 5 N solution NaOH in the course of 6 hours by light boiling over a sand bath. The alkali was neutralized with a 14 N solution of H_2SO_4. The hydrolyzed substance was brought to a definite volume and then filtered.

Incl #2

To determine the remainder of the amino acids an acid hydrolysis was carried out over a sand bath with 6 N solution of HCl in the course of 36 hours. The hydrolyzed substance was filtered after dilution. The hydrochloric acid was removed in a vacuum after which the hydrolyzed substance was brought to a definite volume.

For the analysis of amino acids we used mainly specific methods which do not require any preliminary separation of amino acids. The methods were checked on hydrolyzed casein or gelatin. In all instances (except proline and oxyproline) we obtained fully satisfactory results.

Tryptophane (15, tyrosine (16), phenylalanine (17), methionine (18), cystine and cysteine (19), proline and oxyproline (20), were determined colorimetrically. Glycine and alanine by acidification with ninhydrin and the ensuing colorimetric determination of the resulting aldehydes (21,22). Arginine, histidine, lysine, amino succinic and glutamic amino acids were determined by the enzyme method (23,24) (in the laboratory of B. E. Zbarsky).

The determinations were made on a Schtufenphotometer or on a Specker absorptiometer.

The results of our investigations are tabulated in Table I. This table also shows the amino acid composition of collagen and gelatin (according to published data).

Table I

Amino Acids	In % Dry Ash-free Protein		
	Collagen (25)	Procollagen	Gelatin (26)
Tryptophane	0.0	0.0	0.0
Tyrosine	1.4	0.0	0.44
Phenylalanine	4.2	2.3	2.2
Arginine	8.8	9.2	8.0
Lysine	4.5	4.6	4.1
Histidine	0.8	2.9	0.79
Amino succinic acid	6.3	5.2	6.7
Glutamic acid	11.3	11.0	11.5
Cystine) Cysteine)	0.0	0.0	0.07
Methionine	0.08	0.66	0.61*
Glycine	26.2	28.0	25.5
Alanine	9.5	9.5	8.7
Proline	15.1	(20)	19.7
Oxyproline	14.0		14.4

*In accordance with our data, in gelatin of the hide of a calf.

By comparing procollagen and collagen in their amino acid compositions it can be seen that they contain equal quantities of lysine, glutamic acid, alanine, arginine, amino succinic acid, methionine and glycine and neither of the two contains tryptophane, cystine and cysteine.

Procollagen and collagen differ in their contents of phenylalnine, histidine, proline and oxypoline. Procollagen, unlike collagen, does not contain tyrosine.

Procollagen also differs in its amino acid composition from gelatin as is seen from the data presented in the above table. They contain different quantities of histidine, arginine, amino succinic acid, proline and oxyproline, and, furthermore, gelatin contains tyrosine while procollagen does not.

Thus, on the basis of our data, it can be said that procollagen in its amino acid composition is close to collagen and gelatin but is not identical to them and appears as an individual protein with connective tissues of the collagen type.

I am deeply grateful to Prof. V. N. Orekhovich for his valuable instructions and guidance in the performance of this work.

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BIBLIOGRAPHY

1. Orekhovich, V. N. Biokhimiya 3, 456, 616 (1938)

2. Orekhovich, V. N. Biokhimiya 5, 331 (1940)

3. Orekhovich, V. N. and T. P. Sokllova. Reports of Acad. Sci. 28, 747 (1940)

4. Orekhovvich. Dissertation, 1940; Report, Archives of Biological Sciences 61, 119 (1941)

5. Orekhovich, V. N. Am. Rev. Sov. Med. 6, 517 (1944)

6. Orekhovich, V. N., K. I. Strachitsky and K. D. Orekhovich. Bulletin of Biological and Medical Experiments 22, 60 (1946)

7. Orekhovich, V. N. ibid 22, 57 (1946)

8. Orekhovich, V. N. and A. A. Tustanovsky. Ibid 23, 197 (1947)

9. Orekhovich, V. N. and A. A. Tustanovsky, and K. D. Orekhovich. Reports of Acad. Sci. 57, 475 (1947)

10. Tustanovsky, A.A. Biokhimiya 12, 285 (1947)

11. Orekhovich, V. N., A. A. Tustanovsky, K. D. Orekhovich and N. E. Plotnikova. Biokhimiya 13, 56 (1948)

12. Orekhovich, V. N. Accomplishments in Chemistry 26, 690 (1947)

13. Plotnikova, N. E. Reports of the Acad. Sci. 58, 1715 (1947)

14. Plotnikova, N. E. Ibid 66, No. 6 (1949)

15. Horn, M. I. and D. B. Jones. J.B.C. 157, 153 (1945)

16. Thomas, L. E. Arch. Biochem. 5, 175 (1945)

17. Hess, W. C. and M. X. Sullivan. Ibid 5, 165 (1945)

18. McCarthy, T. E. and M. X. Sullivan. J.B.C. 141, 871 (1941)

19. Nakamura, K. and F. Binkley. Ibid 173, 407 (1948)

20. Guest, G. H. Canad. Journal Research Soc. B17, 144 (1939)

21. Alexander, B., and A. Seligman. J.B.C. 159, 9 (1945)

22. Braunstein, A.E. and Bichkoff. Biokhimiya 8, 5-6 (1943)

23. Sbarski, B.I., I.B. Sbarski and S. R. Mardashev. Biokhimiya 9, 161 (1944)

24. Mardashev and V. N. Gladkova. Biokhimiya 13, 315 (1948)

25. Bowes, I.H. and R. H. Kenten. Biochem. J. 43, 3 (1948)

26. Cohn, E. J. and J. T. Edsall. "Proteins, Amino Acids and Peptides" 1943, p 358.

27. Graham, C. E., H. K. Waitkoff and W. Hier. J.B.C. 177, 529 (1949)

THE AMINO ACID PROPERTIES OF BOVINE PROCOLLAGEN

M. P. Chernikov

(Reports of the Academy of Sciences of the USSR, LXVII, 2, p. 345-9)

V. N. Orekhovich and his associates have been conducting a multilateral investigation of the protein, procollagen, during the course of the last three years (1-12). They have obtained this substance from the skin and internal organs of both man and animals, using a product in crystalline form.

Together with the investigation of biological and physio-chemical properties, and also the distribution of the protein in question in different animals (13,14), there has been work done on the qualitative (N.F.Plotnikova) and quantitative amino acids properties of procollagen. Some of the results of the chemical studies of this protein follow.

Procollagen was obtained from cow hide freshly removed from the animal. The skin was washed, the covering of hair removed, the fat and subcutaneous cellular substance eliminated, and the hide then again washed in running tap water. The skin was ground up in a meat chopper after being cut into small sections. The mash so obtained was used to get albumins, globulins, and procollagen.

After the extraction of albumins and globulins with 1/15 M solution of Na_2HPO_4, the mash was washed with a citrate buffer of pH 3.5. The procollagen was removed with a three-fold soaking in citrate buffer over a period of 3-4 days at a temperature of 2°C. In all cases thymol and toluol were used as preservatives.

An amorphous preparation of procollagen is obtained by adding solid NaCl until a 10% solution was obtained. The protein precipitates as a white mass which is collected by filtration. In order to remove associated proteins, the filtrate is washed a number of times with 5% NaCl solution. In order to remove the salt, the procollagen was soaked in 15-20% acetone and subsequently centrifuged. This operation was repeated until one obtained a negative reaction for chloride ions and a negative Mellon's test, since the absence of tyrosine is a good criteria for purity of procollagen. Thereupon the protein was dried in the usual fashion with acetone and ether.

Procollagen prepared in this way has 0.47% ash, 17% nitrogen, 49% carbon, and 7% hydrogen.

For the determination of tryptophane, tyrosine and phenylanaline, the protein was hydrolyzed in 5N NaOH for six hours, with gentle boiling on a sandbath. The base was neutralized with a 14N solution of sulfuric acid. The hydrolysate was then brought to a definite volume and filtered.

In order to determine the other amino acids, the procollagen was hydrolyzed in 6N HCl for 36 hours, with heating on a sand bath. After dilution the hydrolysate was filtered. The hydrochloric acid was removed in a vacuum and the volume adjusted to some definite amount.

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In order to analyze the amino acids we used the accepted specific methods which do not require a preliminary separation of component amino acids. The process was checked with gelatin or casein. In all cases (with the exception of proline and oxyproline) we obtained fully satisfactory results.

Tryptophane (15), tyrosine (16), phenylalanine (17), methionine (18), cystine and cysteine (19), proline and oxyproline (20) were determined colorimetrically. Glycine and alanine were found by colorometric measurement of aldehydes following oxidation with ninhydrin (21,22). Arginine, histidine, lysine, aspartic and glutamic acids were determined by enzymatic methods (23,24). (In the laboratory of B.E.Zbarckogo)

In Table I is presented the amino acid composition of procollagen with those of gelatin and collagen, obtained from literature. The figures are percentage of dry, salt-free protein weight.

	Collagen (25)	Procollagen	Gelatins(26)	
Tryptophane	0.0%	0.0	0.0	
Tyrosine	1.4	0.0	0.44	
Phenylalanine	4.2	2.3	2.2	
Arginine	8.8	9.2	8.0	
Lysine	4.5	4.6	4.1	
Histidine	0.8	2.9	0.79	
Aspartic acid	6.3	5.2	6.7	
Glutamic acid	11.3	11.0	11.5	
Cystine) Cysteine)	0.0	0.0	0.07	
Methionine	0.8	0.66	0.61	(our own data)
Glycine	26.2	28.0	25.5	
Alanine	9.5	9.5	8.7	
Proline	15.1	(20)	19.7	
Oxyproline	14.0		14.4	

Upon comparing collagen and procollagen according to amino acid composition we can see the following facts: both contain the same amount of lysine, glutamic acid, alanine, arginine, aspartic acid, methionine, and glycine and both do not contain any tryptophane, cystine or cysteine.

Procollagen and collagen differ in their contents of phenylalanine, histidine, proline and oxyproline. Procollagen, in distinction to collagen, does not contain any tyrosine.

A similar analysis can be done for gelatin. We thus see that though procollagen is similar to collagen and gelatin in amino acid composition, it is not identical. We may conclude it is a unique connective tissue protein.

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presented 5/4/49

BIBLIOGRAPHY

1. V.N. Orekhovich, Biokhimiya, 3:456 (1938).
2. " " 5:331 (1940).
3. V.N. Orekhovich & T.P. Sokoloba, Reports of the Academy of Sciences 28:747 (1940).
4. V.N. Orekhovich (dissertation in 1940) unavailable here.
5. " , American Rev. of Sov. Medicine, 6:517 (1944).
6. " , K.I.Strachitskii, & K.D.Orekhovich, Bulletin of Experimental Biology and Medicine, 22:60 (1946).
7. V.N. Orekhovich, ibid, 22:47 (1946).
8. " and A. A. Tustanovskii, ibid, 23:197 (1947).
9. " " and K.D.Orekhovich, RAS, 57:475 (1947).
10. A.A. Tustanovskii, K.D. Orekhovich, and N.E. Plotnikova, Biokhimiya 12: 285 (1947).
11. V.N. Orekhovich, A.A. Tustanovskii, K.D. Orekhovich, and N.E. Plotnikova, Biokhimiya 13:56 (1948).
12. V.N. Orekhovich, Chem. Abstracts (Russian), 26, 690 (1947).
13. N.E. Plotnikova, RAS, 58:1715 (1947).
14. " " 66: ? (1949).
15. M.I. Horn and D.B. Jones, Jour. Bio. Chem. 157:153 (1945).
16. L.E. Thomas, Archives of Biochem., 5:175 (1945).
17. W.C. Hess and M.X. Sullivan, ibid, 5:165 (1945).
18. T.F. McCarthy and M.X. Sullivan, Jour. Bio. Chem. 141:871 (1941).
19. K. Nakamura and F. Binkley, Ibid., 173:407 (1948).
20. G.H. Guest, Canadian Jour. Res., Sec. B., 17:144 (1939).
21. B. Alexander and A. Seligman, Jour. Biol. Chem., 159:9 (1945).
22. A.E. Brachnshtein, et al., Biokhimiya 8:5 (1943).
23. B.I. Zbarskii, I.B. Zbarskii, and S.R. Mardashev., Biof. 9:161 (1944).
24. S.R. Mardashev and V.N. Gladkova, Biof. 13:315 (1948).
25. I.H. Bowles and R.H. Kenton, Biochem. Jour. 43:3 (1948).
26. E.J. Cohn and J.T. Edsall, Proteins, Amino Acids and Peptides, p. 358 (1943).
27. C.E. Graham, H.K. Waitkoff and W. Hier, Jour. Biol. Chem. 17:529 (1949).

(27 is not referred to in text)

Trans. W. Stahl
4/6/51

K. D. OREKHOVICH

(Akademiia Nuak USSR Doklady, 71:521, 1950)

THE PROCOLLAGEN CONTENT OF SKIN IN ANIMALS OF DIFFERENT AGES

A new group of connective tissue proteins - procollagens, which were discovered by V. Orekhovich and A. Tustanovski, has been thoroughly investigated during the course of the last year (1-13). At the present time, we know the chemical composition, chemical and physio-chemical properties of procollagen. There has been much work done on the biological significance of this protein.

In this paper we present some observations based on the last series of experiments devoted to procollagen. The investigations deal with the content of procollagen in the skin of guinea pigs of various ages (from ten days to one year and more).

From the skin of normal, healthy animals we extracted procollagen by the method of A. Tustanovich (3) and determined the amount of this protein by comparing it with the weight of the dry, degreased skin; as well as by comparison to the mass of skin protein--collagen. The skin, removed immediately after killing the animal, was freed from hair, subcutaneous fat and cells, ground-up and treated by the methods given previously (204). The extraction of the protein was repeated five times. The procollagen thus obtained was dried to constant weight. The results are given in table 1.

As we see from table 1, guinea pigs at a young age (from 10 day to 5-6 months) have an amount of procollagen which varies between 7-10%. More mature animals (7-8 months) show a drop to 3-4%, while the old guinea pigs (8 months and older) have only 1-2% of procollagen.

Table 1

Age	Weight when killed (g)	% Procollagen	Age	Weight	% Procollagen
10 days	80-117	6.7*	7-8 months	690	4.0
20 "	120-170	7.3*	"	670	2.9
2-6 months	262	8.2	"	715	2.7
"	287	7.0	"	740	3.0
"	334	8.3	"	760	4.0
"	347	7.5	8 months plus	771	1.0
"	323	10.5	"	800	1.6
"	346	10.4	"	840	3.5
"	367	6.8	"	862	1.8
"	377	14.0	"	875	3.3
"	384	8.4	"	905	6.0
"	400	10.5	"	984	2.6
"	402	9.4	"	1050	1.8
"	448	10.0		1005	3.1
"	454	8.3			
"	535	8.5			
"	547	8.2			

Ref #4

In order to answer the objection that our data depends on the different extraction conditions optimum for older and younger animals, we conducted the following experiment.

We took the skin from five animals weighing 300-400 grams and from two guinea pigs of 725 and 827 g. The mash obtained from these two groups of animals was divided into eight portions. Each aliquot was covered with buffer solution of the following pH: 1.5, 2.0, 3.0, 3.6, 3.95, 4.12, 4.47, 5.02. Procollagen was obtained from the extracts. We found (see Table 2) that the results were the same regardless of the extraction used, and that they also corresponded to earlier conclusions, i.e., that the skin of older animals has several times less procollagen than that of younger ones, although the optimum extraction conditions vary for the two groups.

On the basis of the facts presented above, we can be confident of the fact that as an animal gets older the percentage of procollagen in its skin decreases. It is notable, that in old animals the process of formation of new collagen fibers is also slower. There is reason to suspect that there is some relationship between the formation of collagen and the concentration of procollagen within the skin.

Table 2

THE AMOUNT OF PROCOLLAGEN OBTAINED FROM THE SKINS GUINEA PIGS UNDER DIFFERENT EXTRACTION CONDITIONS

Weight (g)	pH solution							
	1.5	2.0	3.0	3.6	3.95	4.12	4.47	5.02
300-400	11.6	14.3	17.1	12.3	8.8	7.2	12.0	8.8
725, 827	2.4	3.6	3.3	3.6	4.2	4.4	3.4	2.2

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BIBLIOGRAPHY

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Orekhovich, V.N. et al. The procollagen of hide. Biokhimiya 13(1), 55-60 (1948). (Translated from Russian by Mrs. M. Baker)

We have isolated and obtained out of the hides of animals, albumin in crystalline form which evidently belongs to a special group of connective tissue albumin. There are some reasons to assume that it is a biochemical predecessor of collagen, and we therefore named it procollagen (1-4). In this article are given the data of the prevalence of procollagen in the animal world and some facts about the nature of this albumin.

Material and Methods

For the purpose of experimentation animals of various classes of vertebrates and invertebrates were taken. Of the mammals rabbits, rats, calves, dogs and cats were taken; of birds - hens; of reptiles - turtles and grass snakes; of amphibians - frogs; of fish - pike-perch. Besides that, tests were made (for content of procollagen) with human skin and tissues of various species of invertebrate animals.

The hides of animals were taken immediately following their slaughter and the removal of their blood. The outer coverings (wool, scales, feather and horny membranes), hypodermic tissue, fat, etc. were carefully removed and the remaining material was ground up. The resulting paste was used for the purpose of isolation of albumins, globulins and procollagen (crystalline and amorphous).

The albumins and globulins of the animal hides were isolated from the paste by means of five times the volume 0.3 M Na_2HPO_4 within 24-36 hrs. at +2°. The globulins were isolated by adding an equal volume of a saturated solution of $(NH_4)_2SO_4$.

By adding $(NH_4)_2SO_4$ to saturation, the albumins were isolated from the filtrate.

The crystalline procollagen was isolated by the following method. After extraction of the albumins and globulins by means of the phosphate, the remaining paste was washed once or twice with small batches of citrate buffer pH = 4.0. To the washed out paste was added citrate buffer (pH = 4.0) five times the amount by volume (the weight of the paste). This mixture was left at a temperature of (+1°, +2° C) for 24-36 hours. After filtration a transparent viscous solution containing procollagen was obtained. This filtrate was put in collodion or cellophane bags for dialysis under running water or 0.01 M Na_2HPO_4. In 24 hours crystals of procollagen in the shape of long needles were precipitated. The crystalline procollagen was collected on a filter and dried with filter paper. The moist crystals were kept cool. To obtain dry albumin the crystalline procollagen was desiccated with alcohol and ether and then dried to a constant weight at 104-105° or the

dry crystals were obtained by the method previously published by us (1).

Amorphous preparation of procollagen we obtained by the following method. To the citrate extract of the hide paste was added an equal volume of a 10% solution of sodium chloride. The procollagen was isolated from the solution. The precipitate of albumin was collected on the filter and washed several times with a 4-5% solution of sodium chloride. The moist procollagen was kept in the cold.

The ultraviolet spectra of the absorption of the albumin solutions were studied with the aid of a Smith and Hensh quartz spectrograph (medium dispersion) by the method of the threshold of blackening. The source of light was a hydrogen lamp of low voltage of the GOI system.

The procollagen was boiled with crystalline pepsin (2), trypsin and chymotrypsin (prepared by method of Kunitz and Northrop) and preparations of papain and catepsin (an acid glycerine extract from the liver of a rabbit)

Results of Investigations

The Occurrence of Procollagen

We encounter procollagen in the skins of all classes of vertebrate animals.

a. Mammals. We found procollagen in the skin of all the animals we examined (rats, rabbits, calves, dogs and cats). The amount as well as the conditions of its extraction and crystallization vary with different animals. The age of the animal is evidently important. The younger the animal the easier it is to extract the albumin and the easier it crystallizes.

The skin of rabbits contains about 4% of procollagen (to the dry weight of the skin). The albumin crystallizes out of the extracts more completely and much faster with a citrate buffer solution of an initial pH = 3.8. The crystals are in the shape of needles with a maximum length of 260 μ (see diag. 1). Out of the skin of a dog the procollagen is isolated in a much lesser amount, namely 0.6%. The crystals form during dialysis from the extracts with citrate and buffer solutions with an initial pH of from 3.0 to 4.0. The maximum length of the crystals is 130 μ. Crystal procollagen was also isolated from the skin of a cat. The maximum length of the crystals is 130 μ. The albumin crystallizes much faster in the process of dialysis under 0.01 M Na_2PO_4, the crystallization proceeds much slower in the dialysis under running water. Procollagen becomes isolated very easily

out of the hide of a newly born calf. The albumin is crystallized from the extracts with citrate buffer solutions with an initial pH of from 2.0 to 5.4. The yield of albumin is 0.86%. The maximum length of crystal is 195 μ (see diag. 2)

b. Birds. The albumin was isolated from the skin of chicks about 1.5 months old. The crystallized albumin is precipitated from the extracts with buffer solutions of an initial pH 2.7-5.5

c. Reptiles. The albumin was isolated from the skin of a Middle Asiatic desert turtle. The procollagen of this reptile discloses the peculiarity that the albumin crystals can be obtained only if the pH of the citrate buffer solution (used for extraction) does not exceed 3.0 and the dialysis is carried out under 0.01 M Na_2HPO_4 but not under running water. The maximum length of crystals is 52 μ. So far we have not succeeded in isolating the procollagen from the skin of a grass snake.

d. Amphibians. Crystalline procollagen in only very small quantities can be obtained from the skin of frogs (Rana temporaria). The dialysis of the extracts is better under a solution of Na_2PO_4. Maximum length of crystals is 65 μ.

e. Fish. The skin of fish, seemingly, contains the largest amount of procollagen. 2.5% of procollagen (dry albumin with dry weight of skin) was obtained from the skin of a pike-perch. The albumin passes into the solution very easily and crystallizes in the dialysis under running water as easily as under 0.01 M Na_2HPO_4. The albumin crystals precipitate from all the extracts with citrate buffer solutions with a pH of from 3.5 to 5.5. The maximum length of crystals is 90 μ. So far we failed to isolate the procollagen from the tissues of the invertebrates. It is possible that the modes of extraction of this albumin have to be different from the ones developed by us in the case of vertebrates.

The Nature of Procollagen

Procollagen is a globular albumin soluble in acidified water and not soluble in neutral and weak alkaline medium. In concentrated solutions it has a very high viscosity. It precipitates from solution even in the presence of small concentration of sodium chloride (5%) and other neutral salts. In amino acidic composition it approaches collagen and gelatin, but in solubility and salting out and other properties it differs from them. During boiling of the solutions or during suspension, procollagen turns to gelatin.

Below we will describe certain facts which characterize the nature of this albumin.

a. Ultraviolet Absorption Spectra. We have made a study of the ultraviolet absorption spectra of solutions of procollagen, albumin and globulins of skin and gelatin.

Diag. 3. Ultraviolet absorption spectra of solution of albumin and globulin of skin. The unbroken line is that of albumin and the dotted line is that of globulin.

For analysis we prepared 1, 3, 4, 6 and 10% acidified water solutions of procollagen (pH of solutions from 2 to 5), 1, 3, 5, 6 and 10% water solutions of gelatin from the hide of a calf (pH of solutions from 2 to 7). Since the majority of the above indicated solutions at room temperature form a jelly, it was necessary to heat the solutions to 30-35° in order to fill the cuvette of the spectrograph. Albumins and globulins of the skin were used in the form of 0.75% salt solutions of albumins (pH of solution - 6.5-7.0).

Solutions of albumins and globulins of skin give a typical albumin spectrum with a maximum absorption of about 2,800 A (see diag. 3) which is defined in these albumins by the presence of considerable quantities of tyrosine and tryptophane. In the spectra of procollagen solutions, the characteristic maximal absorption is absent and only in the spectra of concentrated (over 3%) solutions of albumin there are 5 absorption lines, three of which have a width of 30 A each and 2-20 A each. These lines lie between 2570 and 2,600 A; 2,640-2,660 A; 2,690-2,710 A; 2,760-2,790 A; 2,840-2,870 A (see diag. 4).

In the spectra of 6% and 10% solutions of gelatin obtained from the hide of a calf, we succeeded in detecting only 3 absorption lines 2,570-2,600 A, 2,640-2,660 A and 2,680-2,700 A (diag 5). Comparing the absorption spectra of these two albumins it is seen that the absorption lines for gelatin noted by us are identical with the corresponding lines in the absorption spectra of procollagen. The next 2 lines of absorption which lie in the longer wave section of the ultraviolet we could not detect in the spectra of the gelatin solutions. As is known (5), the characteristics of absorption spectra of gelatin are dependent upon the absence from the albumin of tyrosine and tryptophane and on the presence of phenylalanine. On the basis of the above-mentioned facts we can assert that phenylalanine is also present in procollagen. For the time being we cannot explain on what the characteristic of the absorption spectrum of procollagen depends.

b. The Relationship of Procollagen to Proteinases. We made a study of the digestibility of crystalline procollagen with various proteolytic enzymes. It became clear that this albumin is well digested by tissue proteinases (catepsin and papain) and comparatively poorly by the proteinases of the digestive system

(pepsin, trypsin and chymotrypsin) (see table below)

TABLE I

The Intensity of Fermentative Hydrolysis of Procollagen at Various pH Media

Enzymes	Increase of Amino Nitrogen in 24 hrs. in specimen (in mg.)									
	pH									
	2.3	3.2	3.67	4.0	4.4	4.5	4.9	5.60	6.0	7.8
papain	1.30	1.40	2.10	0.90	1.50	--	1.50	--	1.60	--
catepsin	0.0	0.70	1.90	2.30	--	2.20	--	1.60	1.10	--
pepsin	0.0	0.50	0.90	0.0	--	0.60	--	0.30	--	--
trypsin	--	--	--	--	--	--	--	--	--	1.00
chymotrypsin	--	--	--	--	--	--	--	--	--	0.60

In the process of hydrolysis of albumin in 24 hours here is liberated in the form of free amino nitrogen, the following percentages of the entire albuminous nitrogen: with catepsin - 40%; under action of papain about 30%; by hydrolysis with trypsin only 15%; with pepsin 14%; and with chymotrypsin 9%. Denaturing of albumin by boiling has no effect on the extent of its hydrolysis with trypsin and chymotrypsin.

Chemical Composition of Albumin

We have already published certain data about the elementary composition of procollagen from the skins of rats and rabbits. In highly purified and multiprecipitated procollagen there is: carbon 49%, nitrogen 16%, hydrogen 7.5% (averages).

A small amount of phosphorus (0.15%) which is found in procollagen we are inclined to attribute to impurities which are difficult to isolate by methods available to us. On the basis of results from the ultraviolet spectrography we can already conclude that procollagen definitely or almost definitely does not contain tyrosine or tryptophane. On the basis of chemical reactions we have established that there is no tyrosine (Millon's reaction negative) and only traces of tryptophane (xanthoproteic reaction and voisene reaction). Reactions for sulphur are negative. We isolated from albumin histidine (in the form of nitroanilide), arginine (in the form of flaviamide) and lysine (in the form of nitroanilide). The general content of diamino acids about 5%.

Procollagen contains over 10% of dicarboxylic acids (isolated by us in the form of barium salts). Albumin contains a considerable amount of proline and hydroxyproline. The reaction for carbohydrate is positive.

Conclusions

The albumin of skin which according to our tests possesses a high biochemical instability when isolated in crystalline form, differs in a series of characteristics from heretofore known albumins. It may be assumed that it is a forerunner of collagen and is, therefore, named procollagen by us.

It seems to us that there is basis to classify this albumin in a special group of connective tissue albumin and that procollagen will not be the only representative of this group. Procollagen is widely spread in the animal world and it is safe to say that there are not any species of vertebrates which do not contain this albumin. According to our tests, procollagen is present not only in the skin but also in a series of other tissues and organs of animals. In particular, it was possible to isolate from the tendons of a bull a crystalline albumin which resembled the procollagen of skin. It will be of interest to compare the identity of the procollagen isolated by us with the crystals of albumin in compounds of the sinews of a rat's tail as observed under a microscope by Nageotte and with the amorphous compound of collagen like albumin isolated from the skin.

We consider it our duty to express our thanks to our collaborator K. D. Leontgeva of the physiochemical laboratory for her great help in spectrography

Titles of Diagrams

Diag. 1. Crystalline procollagen from the skin of a rabbit.

Diag. 2. Crystalline procollagen from the hide of a calf.

Diag. 3. (explained in text)

Diag. 4. Ultraviolet absorption spectrum, 4% solution of procollagen

Diag. 5. Ultraviolet absorption spectrum, 6% solution of gelatin

Bibliography

1. Orekhovitch and A. A. Tustanovsky. Experiments in biochemistry and medicine, XXIII, 5, 1947.

2. Orekhovitch, V. N., A. A. Tustanovsky and K. D. Orekhovitch. D.A.N. 57, 5, 1947

3. Tustanovsky, A. A. Biochemistry 12, 285, 1947

4. Plotnikova, N. E. D.A.N, 58, 8, 1947

5. Rousseetot. J. chim. phys. 40, 85, 1943

6. Nageotte. C. R. Soc. Biol. 96, 172, 1927

7. Leplat. C. R. Soc. Biol. 112, 1256, 1933

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CONCERNING THE METABOLIC TURNOVER RATES OF VARIOUS ORGAN AND TISSUE PROTEINS

Akademiia Nauk SSR Doklady, 71:105, 1950

It is well known that there is a continuous renewal of the parts of an organism; that its proteins, fats and carbohydrates do not remain unchanged after their synthesis and inclusion in organs or tissues, but are constantly being turned-over. Naturally, the study of this process is a very essential and important part of the deciphering of the functions of the organism. This is especially interesting from the standpoint of proteins.

For our studies we have made use of tagged atoms to determine the turnover rates of different organ and tissue proteins and their separate fractions. This problem has been studied by Schoenheimer and his associates (1), who made use of tagged amino acids. They only investigated the time for inclusion of these substances into different proteins, but not the overall turnover rate of the protein. Using and Krough ? investigated the overall renewal of proteins with the aid of a heavy hydrogen isotope (deuterium), carried in the form of heavy water. They were only interested in the turnover rates of proteins of the skin, muscles and some internal organs.

We also made use of heavy water, studying the turnover rate of proteins from the organs and tissues of white rats, as well as some of their constituent fractions.

Heavy water was given to the animals at such a rate that after a few days its concentration in the body reached 1%. Then the animals were killed and proteins extracted from all organs and tissues. The proteins were carefully treated to remove physically bound water, dried to constant weight and incinerated. After being suitably cleansed, the water formed was analyzed for atom per cent deuterium by the flotation density method.

The data we obtained are presented in Table 1. It is seen that the fastest turnover rate occurs in the proteins of the liver, while that of the skin and muscles is the slowest. The rest of the investigated proteins lie between these limits.

We tried to characterize the turnover rate of proteins not only with respect to how fast they took up deuterium, but also as to how fast they lost it again. With this goal we worked with a group of rats which were given heavy water for twelve days and then not killed immediately, but after twelve more days had elapsed.

Incl #6

Table 1

TURNOVER RATES OF PROTEINS OBTAINED FROM VARIOUS ORGANS

Organ	Excess of deuterium (at %) after introduction of D O	Turnover rate (%) of proteins	Excess of deuterium (at %) after stopping introduction of D_2O	Difference (%)
Liver	0.232	23.3	0.109	0.123
Intestine	0.170	17.0	0.094	0.076
Spleen	0.167	16.7	0.107	0.060
Kidneys	0.162	16.2	0.079	0.083
Stomach	0.137	13.7	0.084	0.053
Heart	0.136	13.6	0.106	0.030
Lungs	0.115	11.5	0.078	0.037
Brain	0.112	11.2	0.092	0.020

As we see from the data presented in Table 2, the rate of loss of deuterium from proteins of organs and tissues is not the same as their rate of uptake. For example, the uptake of deuterium by the kidneys ranks fifth, while it is second as far as rate of loss is concerned.

Table 2

LOWERING OF THE AMOUNT OF DEUTERIUM IN PROTEINS OF VARIOUS ORGANS 12 DAYS AFTER IT CEASED BEING PRESENTED (%)

ORGAN	% DECREASE
Liver	53
Kidneys	54
Intestine	40
Stomach	38
Lungs	31
Spleen	30
Heart	22
Brain	19

There is the same lack of correspondence in the uptake and loss rates of the proteins from lungs and stomach. This is explained, apparently, by a difference in intensity of exchange rate of structural moieties between various organs. The disproportionally low figure for kidneys can be explained not only by the intensity of turnover of amino acids containing deuterium, but also, apparently, because of the dilution of their own structural proteins with those from organs which contain a low concentration of the isotope.

Together with the study of the intensity of the turnover rate of the proteins from different organs and tissues, we also study the turnover of various protein fractions derived from the same organ. We anticipated that by this method we would be able to answer the question, to what ext

turnover rate for all the proteins of a given

organ is specific for individual fractions which go into the makeup of the organ. The figures we obtained are presented in Table 3.

Table 3

INTENSITY OF TURNOVER OF VARIOUS PROTEIN FRACTIONS FROM DIFFERENT ORGANS

Protein	Excess of deuterium (at %)	Turnover rate (%)
Blood proteins	0.181	18.1
Blood globulins	0.148	14.8
Liver glovulins	0.137	13.7
Skin globulins	0.138	13.8
Albumins and globulins of the skin	0.177	17.7
Collagen of the skin	0.132	13.2
Procollagen of the skin	0.123	12.3
Ossein (collagen ?)	0.115	15.5
Muscle proteins	0.101	10.1
Myogen	0.089	8.9

As can be seen from this data, the turnover rate of globulins of the blood, liver and skin is practically the same, while the intensity of turnover of the collagen of the skin is much lower than the skin globulins. In this way we can see that the turnover rate of the fractions varies in each given organ.

Besides examining the turnover rates in normal adult rats, we also studied them in newborn animals and their mothers. For these experiments we fed a pregnant rat heavy water for twelve days before the birth of her litter. The same day that the rats were born they were killed, together with their mothers, and proteins from different organs analyzed for their content of deuterium. The results are given in Table 4.

Table 4

INTENSITY OF TURNOVER IN ATOM PERCENT OF DEUTERIUM

Tissue	Excess atom-%		Protein turnover %	
	Mother	Newborn	Mother	Newborn
Skin	0.070	0.236	7.0	23.6
Internal organs	0.187	0.254	18.7	25.4
Carcass	--	0.264	--	26.4
Muscles	0.070	--	7.0	--
Head	--	0.252	--	25.2

As we can see from Table 4, the turnover rate of the proteins of the skin and muscles of the mother is markedly less than that of normal adult rats (Table 1). This indicates that there is a sharp decrease in turnover rate of muscle and skin proteins during pregnancy. The turnover rate for the internal organs of the mother is normal. The proteins of all the tissues of the new born animals show almost the same excess of deuterium, which is much higher than any of the rates of the tissues of the mother. This may be explained, perhaps by the fact that all the organs and tissues of the embryo are being built up of free amino acids, without its making use of the formed proteins of its mother's organism.

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BIBLIOGRAPHY

1. R. Schoenheimer, The Dynamic State of the Body Constituents, 1942

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Walter Stahl
4/27/1951

Tutanovskii, A. A., "Concerning the proteins of skin." Biokhimiia, 12(4): 285-90. 1947

A crystalline protein resembling collagen is obtained from rabbit or rat skin by the following procedure: Shredded skin, freed from muscle, porous epidermis and superficial fat, is extracted with 0.1 M buffer composed of completely or partially neutralized organic acid (citric, succinic, oxalic, lactic, tartaric, adipic or glutamic). The optimum pH for extraction varies with the type of skin and the organic acid employed. In the extraction of rat skin the optimum pH is 3.5 for oxalic acid buffer and 4.1 for citric acid buffer, while in the extraction of rabbit skin with citric acid buffer the optimum pH is 5.7. Extraction with 5-6 ml. of buffer/g. of skin requires 12 hours under mechanical agitation. Extraction and subsequent operations are carried out at 7-8 C. The buffer extract is clarified by centrifugation and filtration. The filtrate is dialyzed against water, pH 7-8. When the buffer concentration falls to below 0.01 M, crystal separation occurs spontaneously. Crystals are predominantly needle-like, length 25-750 microns, diameter 5-6 microns. 100 g. of fresh rat skin yields 2.7 g. of dry crystalline protein. - M. C. Brockmann

Vol #7

A. L. Zaydes and S. L. Pupko
(Akademiia Nauk USSR Doklady, Vol. 73: 991, 1950)

ELECTRON-MICROSCOPIC INVESTIGATION OF THE EFFECTS OF ALKALIS AND PANCREATIN ON COLLAGEN

The electron microscopic examination of collagen has disclosed the presence a regularly repeating structural pattern in the fiber (1).

There is a strong interest in the effects of various treatments on this structure. Since the production of collagen by the skin involves the presence of specific fluids and enzymes of the pancreas--pancreatin, we decided to study the influence of these reagents first, especially since the illucidation of the action of lime on collagen is inadequate (2), and the literature on the enzymatic treatment is totally lacking.

Pieces of collagen, obtained from the frontal part of a steer skin, cut in a size 2 x 10 cm. were processed with a solution of lime-water containing calcium hydroxide in a concentration of 10g/l. They were kept in this suspension over a varying period of time, ranging from four days to two years. Before examination, the swollen fibers were neutralized in 5% bisulfite and carefully washed.

The enzymatic treatment of fibers kept in alkali for four days and then neutralized was carried out with a one per cent solution of pancreatin at a temperature of 37°C, for periods of 3 hours, 8 hours, 12 hours, and four days, with constant agitation all the while. With the protracted pancreatin treatment, we used a daily change of pancreatin solution.

Then the collagen was washed with water and dried in ether-alcohol.

From the prepared tissues we cut sections in a freezing microtome; they were then dispersed for five minutes in a magnetostrictive apparatus with a frequency of about 8 kilohertz.

The dispersed collagen was placed on a collodion film and shadowed with chromium for increased contrast, using an angle of 15°.

The results show that treatment with limewater over a period of four days causes absolutely no change in the structure of the collagen (Fig. 1a). With collagen soaked for a month we begin to see disruption of the structure, which becomes more marked upon two months' processing. Together with regions without local changes, we can see strongly deformed fibrils, mixed up among each other and with a loss of periodic structure (Fig. 1,b).

A complete lack of regular structure is seen in collagen after two years of treatment with calcium hydroxide solution (Fig. 1,c).

We thus conclude that the limewater has to act a long time to cause complete breakdown of structure; its action is slow and irregular.

Ref # 8

A similarly unpredictable change in form is caused by the action of pancreatin. But the character of the alteration is quite different.

Enzymatic treatment carried out over a period of three hours does not change the typical electron-microscopic picture of collagen.

It is interesting to note that the indicated duration of treatment corresponds to collagen produced in a certain way, and that our experiments under these conditions showed absolutely no alteration in the finest details we could resolve.

In proportion to extended treatment in enzymatic solution, a destruction of the collagen starts to appear gradually. In the e.m. picture of material processed for 8 hours, we can see badly damaged regions together with ones that show clearly defined striations (Fig. 2,a). Treatment over the course of 12 hours causes partial unraveling and breakdown of the fibers (Fig. 2,b), while four-day digestion yields material with no regularity at all, giving just "debris" under the electron-microscope (Fig. 2,c).

In one of our papers (3), we noted that electron-micrographs of replicas of all collagen fibrils gave a definite orientation of perpendicular bands. Similarly with dispersed fibers, we noted this regularity of structure in all fibrils which could be observed close enough to each other. We can see in Fig. 3 that the dark and light regions correspond in adjacent fibers. This is an adequate proof of the organized spatial arrangements of the molecular micelles found in collagen.

We are indebted to A. N. Mikhailov and A. I. Frimer for their interest and work.

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BIBLIOGRAPHY

1. A. L. Zaides & S. L. Pupko, RAS, 65:227, 1949
2. G. Nutting and R. Borasky, Journ. Am. Leather Chem. As. 43:96, 1948
3. A. L. Zaides and S. L. Pupko, RAS, 73: ? (1950)

Translated by:
Walter Stahl
4/18/1951

DIAGRAM CAPTIONS

Fig. 1 Collagen treated with milk of lime, dispersed with sound and shadowed with chromium. Length of treatment: a-4 days, b-2 months, c-(beta)-2 years

Fig. 2 Collagen after enzymatic treatment, dispersed with sound and shadowed with chromium. Length of enzymatic treatment: a-8 hours, b-12 hours, c-4 days

Fig. 3 Ultrastructure of fibrils, dispersed with sound and shadowed with chromium

Popko

Zagdes, A. L. and S. L. Popko. The electron microscopic examination of collagen. Reports of the Acad. of Sci. of USSR LXV, 2, pp. 227-8, 1949. From the Central Research Inst. of the Leather-footwear Industries.

The electron microscope examination of the primary fibrous protein of the skin, collagen, is of interest from two viewpoints. It is, of course, allowing the growth of ideas about collagen itself and its production by the skin. But it is also shedding light on the nature of fibrous proteins, in general, which are more widely distributed.

To the present time x-ray analysis has been used to examine the fine structure of collagen. This did not allow, however, the examination of the form and inter-relation of the elements of the subfibrils whose thickness ranges from 100-50 A.

For the electron microscopic examination of collagen we used both direct observation and replica technique. Our exmination by the latter method confirmed the earlier observations of the etructure of this material (1).

A more thorough method of direct observation was the result of sectioning in a microtome to a thickness of a few microns and then dispersing with ultrasonic vibrations of frequency of about 8,000 c.p.s. for 3-5 minutes. The preparations so obtained were deposited on films of collodion or aluminum oxide and shadowed with chromium to give more contrast (2).

Untreated fibers were examined, as well as those stained with various salts of heavy metals and extracts from wood of the oak.

All examinations of the fibers have revealed periodic bands which are arranged perpendicular to the long axis or as a spiral. The spiral form appeared very sharply in some of the photomicrographs.

When different forms of treatment are used, the width of the striations changes, revealing still finer bands within. Thus, material treated with tan-bark extracts shows an over-all spacing of about 700 A and a band width of about 170 A.

The polysterol-quartz replica of untreated collagen fully confirms the above findings (2).

Similar results are also obtained through the use of methyl-methacrylate-quartz replicas which avoid the necessity of heating the object during preparation.

Electron microscopic examinations of collagen fibers by American authors (3) gives the following picture of its structure. The wide bands of the collagen subfibrils consist of several smaller bands which show a characteristic, periodic density. The bands extend the width of the whole fiber. This conclusion is

not in agreement with our own experimental results.

If the subfibril really has the chain form given above, replicas of individual fibers should show the form of the fiber without its internal structure. Electron photomicrographs prepared by us, however, show a periodic structure consisting of two mutually perpendicular spirals of subfibrils.

These observations bring us to the conclusion that the molecular components of collagen show a contour structure.

The accompanying electron microphotographs (none) of untreated, shadowed collagen fibers (chromium) show the outer structure of the material. The shadows show the same periodic structure, proving the presence of the relief.

The observation of fibers at the moment of bursting due to the action of the electron beam on the fiber or supporting film has confirmed the above conclusion. The break always occurs at the lightest, and then the most thin, bands. The more dark, and therefore dense, bands then take on the form of an extended droplet. In the broken fibers the spacing between the light and dark bands is still more apparent, supporting the above hypothesis.

It is interesting to note that the broken fiber takes on a more uniform appearance when stained with phosphotungstic acid, apparently due to a more uniform absorption of the metal.

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Bibliography

1. Schmitt, F., C. Hall and M. Jakus, Biol. Symposia 10, 261 (1943); C. Wolpers, Virchows Archiv. 312, 292 (1944); G. Nutting and R. Borasky, J. Am. Leather Chem. Assoc. 43, 96 (1948).

2. Firmer, A. E. and S. L. Poupko, Director of above laboratories.

3. Schmitt, F., C. Hall and M. Jakus, J. Cell. Physiology and Comp. Physiol. 20, 11 (1942).

Presented to Academy on January 15, 1949 by A. E. Oparin

Diagrams

Fig. 1. Unraveled collagen
Fig. 2a. Native collagen; 6-stained with phosphotungstic acid; β-uranyl acetate stained; γ-oak extract treated.
Fig. 3a. Chromium shadowed collagen fiber; 5-polysterol quartz replica of collagen
Fig. 4. PTA treated fiber distorted by bursting of underlying film.

Translated by Walter Stahl

(Akademiia Nauk USSR Doklady, Vol. 73:379, 1950)

THE ELECTRON-MICROSCOPIC EXAMINATION OF COLLAGEN USING THE REPLICA TECHNIQUE

The primary advantage of the replica technique for examining collagen (1) lies in the fact that it does not require that the fibers be treated in any structurally-disturbing way (for instance, as in dispersion by sonic vibrations) and that one can obtain the impression of a block of material, according to which it is possible to judge the architecture of the tissues. The investigations of collagen by the collodion replica technique available in the literature (2) deal with samples of the fibers first dispersed by various methods (sonic vibration, colloid mill, mechanical unraveling with needles). By this method one obtains imprints of single fibers only, since by such treatment the histological structure of the collagen is destroyed.

Together with the study of dry objects by the use of polysterol-quartz replicas, we have worked out a method of getting replicas of wet materials. To achieve this goal we heat an aliquot of methyl methacrylate monomer in a reflux condenser, adding the polymerization catalyst. This is carried on until the liquid becomes slightly viscous. Then the top layer is cut off a piece of collagen in a freezing microtome and the remaining material is submerged in water.

After recovering the block from the water, the surface chosen for examination is freed from excess water by using a piece of filter paper for drying (this process must be carried out rapidly). On a surface prepared in this way is poured the freshly prepared and slightly polymerized methyl methacrylate. In order to prevent drying, the specimen is covered with the liquid on all sides. The consequent polymerization process takes place on the object itself. The first layer of thin film is reinforced by a secondary coating of polymer until a thickness is built up which makes it convenient to remove the film (about 0.1 mm). Then the film is taken off and it is dusted with quartz in a vacuum to give a thin film (order of 100-300 A), applied on the side facing the collagen. The quartz film is freed from the methacrylate by dissolving the latter away with dichlorenthane.

Using the replica method we examined specimens of collagen which were untreated and some which we prepared in various ways: in calcium hydroxide, enzymes (pancreatin), salts of heavy metals (PTA, PMA, and uranyl acetate), fixed in formaldehyde, primary sulfate of chromium and woody oak extract. In all cases we observed the presence of regular perpendicular bands of different densities (see figs. 1,a,b; 2,a,b; 3,a,b).

We were able to observe a greater differentiation on the replicas from wet fibers than on corresponding dried ones. Thus, in the case of the chrome-tanned material, besides the 634 A period there was one of 297 A. By ordinary observation in the electron microscope we observed roughly the same period (282 A) in collagen fibrils. In some of the replicas, obtained from the specimens treated with extract of the woody oak, we were able to see spherical particles lying on the fibrils (see fig. 4). In all probability, these particles are composed of tanning, not part of the collagen but only adsorbed on its surface.

Ind #10

Calculations show that the repeating period is maintained with an accuracy of about ±15 A. The periodicity is observed to the limits of each method of preparation (see table 1). We can divide the observations on the periods into three groups: 1--with a repeat period of 640 A in the wet state; 2--the period of dry, untanned objects (here too are specimens treated with PTA and formaldehyde) which ranges from 540 - 560 A; 3--a period for fibers treated with various tanning agents and dried, which is about 430 A.

Table 1

REPEAT PERIOD OF THE FIBER

Form of treatment	Repeat Period in A	Fiber Width in A
USING POLYSTEROL-QUARTZ REPLICAS OF DRY FIBERS		
Untreated	535	650
Calcium hydroxide (3 days)	575	980
" " (1 month)	546	-
Pancreatin (3 hours)	546	820
" (12 hours)	540	1140
P.T.A.	556	910
Formaldehyde	586	990
P.M.A.	466	800
Uranyl acetate	426	705
Primary sulfate of chrome	409	800
USING METHYL METACRYLATE-QUARTZ REPLICAS ON WET OBJECTS		
Calcium hydroxide (3 days)	640	-
Pancreatin (8 hours)	640	-
Pancreatin (12 hours)	625	-
Primary sulfate of chrome	634	1200
Extract of woody oak	651	1100
Formaldehyde	609	1100

Replicas have not only allowed us to elucidate the repeat periods of fibrils, but also the relative constancy of their width. For the various forms of collagen treatment the average width is about 0.1 microns. In the case of the wet fibers, tanned with the primary sulfate of chromium and formaldehyde, calculations show an increase in width of about 1020%.

Replicas of all the examined fibers show a definite orientation of the bands in different fibrils; the dark bands as well as the light coincide. This fact, and also the constant period of repetition, is characteristic of the collagen structure, indicating a definite spatial arrangement of molecular groups.

In conclusion, we are obligated to express our thanks to A. N. Mikhailov and A. I. Firmer for their interest and work.

Central Scientific-investigating Institute
of the Leather-wear Industries of the USSR

Presented:
6/14/1950

QUOTED LITERATURE

1. A. L. Zaides and S. L. Pupko, Doklady, 65: 1948
2. J. Gross and F. O. Schmitt, Journ. Exp. Med., 88:555, 1948

Translated by:
Walter Stahl
4/24/51

[redacted]

Date	January			February			March			April			May			June		
	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall
1	57	39	0.02	61	41	0.17	50	30	-	63	39	-	84	54	-	98	64	-
2	50	37	-	52	39	0.06	57	34	-	70	43	-	86	59	-	91	69	-
3	52	39	-	57	37	-	55	30	0.01	72	46	-	81	58	-	90	63	-
4	57	45	0.10	59	36	-	52	30	-	73	46	-	77	48	-	90	61	-
5	59	41	-	63	36	-	57	36	-	81	50	-	73	50	-	91	63	-
6	61	41	-	61	37	0.03	59	39	0.11	88	57	-	81	54	-	95	64	-
7	54	43	-	59	37	-	55	34	-	72	52	0.03	88	57	-	99	66	-
8	61	36	-	61	36	-	59	34	-	79	46	-	90	61	-	99	68	-
9	57	39	0.03	57	37	-	59	36	-	75	46	0.05	91	61	-	99	68	-
10	57	36	-	46	27	-	63	37	-	73	43	-	91	59	-	100	66	-
11	54	34	-	46	34	-	66	37	-	73	48	-	88	61	-	100	66	-
12	59	34	-	55	28	-	72	43	0.32	86	54	-	90	57	-	97	66	-
13	54	39	0.19	59	39	-	61	39	-	90	50	-	91	64	-	95	64	-
14	46	34	-	61	34	-	64	41	-	72	43	-	82	54	-	91	68	-
15	52	36	0.31	57	34	-	59	39	0.44	70	54	-	82	52	-	95	68	-
16	45	34	0.09	59	34	-	48	36	-	79	52	-	77	54	-	100	66	-
17	55	43	0.03	61	41	-	59	41	-	79	52	-	79	54	-	99	63	-
18	48	34	0.13	61	37	-	59	41	0.05	79	48	-	82	57	-	95	64	-
19	48	43	0.04	59	39	-	61	32	-	73	48	-	84	57	-	97	66	-
20	55	41	-	66	46	0.04	59	37	-	81	55	-	88	61	-	99	68	-
21	55	41	-	59	43	-	68	43	-	86	61	-	90	59	-	100	68	-
22	52	41	0.04	68	48	-	66	48	-	93	63	-	93	61	-	102	68	-
23	52	39	-	64	39	-	66	43	-	99	70	-	95	64	-	100	73	-
24	57	43	0.02	61	37	-	70	50	-	93	61	-	100	64	-	104	73	-
25	54	36	-	61	36	-	66	45	-	90	70	-	97	61	-	104	75	-
26	54	39	0.01	50	25	-	68	45	-	95	61	-	91	55	-	106	73	-
27	54	36	-	43	27	-	70	55	-	100	55	-	84	59	-	108	73	-
28	54	34	-	41	25	-	73	52	-	86	63	-	88	61	-	106	73	-
29	59	34	-	-	-	-	82	43	-	91	50	0.01	88	61	-	102	72	-
30	52	37	0.15	-	-	-	64	36	-	82	54	-	90	61	-	102	75	-
31	55	39	-	-	-	-	61	39	-	-	-	-	93	63	-	-	-	-

SHADE TEMPERATURES (FAHRENHEIT) AND LAWN MOWER RAINFALL FOR 1938 (cont'd)

Table 1-2

Date	July Max.	July Min.	July Rain Fall	August Max.	August Min.	August Rain Fall	September Max.	September Min.	September Rain Fall	October Max.	October Min.	October Rain Fall	November Max.	November Min.	November Rain Fall	December Max.	December Min.	December Rain Fall
1	104	75	-	108	75	-	106	73	-	81	52	-	88	61	-	64	41	-
2	102	77	-	104	72	-	108	72	-	82	48	-	88	57	-	66	46	-
3	99	70	-	106	73	-	106	73	-	88	55	-	86	59	-	68	45	-
4	100	72	-	106	72	-	106	70	-	93	55	-	79	59	0.11	64	39	-
5	100	73	-	102	72	-	106	70	-	88	57	-	75	48	0.03	68	42	-
6	102	75	-	104	72	-	102	68	-	81	60	-	70	48	-	66	39	-
7	109	79	-	108	75	-	100	68	-	88	57	-	70	48	0.01	63	41	0.04
8	109	82	-	108	75	-	100	66	-	88	57	-	64	39	-	63	41	-
9	108	84	-	104	72	-	97	70	-	88	57	-	64	45	-	64	48	0.21
10	108	77	0.01	104	68	-	97	70	-	86	52	-	64	45	-	63	41	-
11	108	81	-	100	70	-	97	68	-	75	50	-	66	39	-	61	43	-
12	108	81	-	102	73	-	97	66	-	79	46	-	63	37	-	59	41	-
13	108	77	-	99	72	-	106	72	-	81	52	-	66	36	-	54	45	0.02
14	106	75	-	100	73	-	97	64	-	86	55	-	63	36	-	54	37	-
15	108	72	-	106	75	-	99	66	-	93	59	-	64	41	-	52	28	-
16	104	72	-	109	73	-	95	66	-	88	61	-	66	35	-	52	43	0.06
17	100	72	-	104	68	-	89	63	-	86	57	-	66	37	-	54	45	-
18	100	72	-	102	70	-	90	63	-	86	57	-	66	37	-	55	34	-
19	99	79	-	104	72	-	91	63	-	88	59	-	63	36	-	59	41	-
20	99	68	-	106	72	-	91	61	-	95	59	-	68	39	-	55	36	-
21	100	68	-	102	70	-	86	59	-	81	52	-	68	37	-	57	34	-
22	99	68	-	99	72	-	87	59	-	82	57	-	70	37	-	63	34	-
23	102	73	-	99	73	-	88	68	-	82	55	-	68	39	-	64	36	-
24	104	75	-	100	75	-	91	64	-	77	50	-	70	39	-	48	43	-
25	106	75	-	104	72	-	86	58	-	77	50	-	68	43	0.01	55	36	-
26	106	75	-	104	72	-	87	59	-	77	50	-	70	45	0.20	59	36	-
27	108	72	-	104	72	-	86	60	-	77	50	-	72	39	-	59	37	-
28	108	73	-	104	73	-	81	53	-	81	54	-	72	43	-	59	48	0.37
29	108	73	-	102	73	-	77	54	-	80	61	-	70	45	-	55	43	0.19
30	109	79	-	104	70	-	77	50	-	86	61	-	72	45	-	61	39	-
31	109	77	-	100	75	-	-	-	-	88	61	-	-	-	-	61	43	-

SHADE TEMPERATURE (DEGREES F.) AND RAINFALL FOR 1935

Date	January			February			March			April			May			June		
	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall
1	61	34	0.02	54	36	-	66	36	-	77	37	-	102	52	-	106	61	-
2	59	41	-	55	37	0.16	66	36	-	84	48	-	102	57	-	108	70	-
3	55	39	0.17	52	39	-	66	41	-	68	46	-	102	55	-	109	68	-
4	59	39	-	48	37	0.11	68	41	-	70	37	-	99	64	-	108	61	-
5	59	37	-	48	32	-	68	41	-	73	43	-	95	64	-	106	68	-
6	57	36	-	55	34	-	70	37	-	77	48	-	93	57	-	104	64	-
7	54	37	-	46	32	-	66	37	-	81	48	-	81	68	0.03	102	66	-
8	54	37	-	48	32	-	68	34	-	86	43	-	80	60	-	100	72	-
9	50	32	-	59	30	-	75	36	-	70	57	0.14	86	57	-	102	68	-
10	50	36	-	59	36	-	81	39	-	70	55	0.10	91	54	-	105	61	-
11	48	27	-	70	39	0.08	61	39	-	63	50	0.35	93	50	-	108	72	-
12	46	23	-	59	41	-	68	41	-	68	50	0.05	93	70	-	102	68	-
13	48	27	-	70	41	0.04	72	32	-	70	43	-	91	63	-	99	66	-
14	50	30	-	52	41	0.25	73	34	-	77	45	-	95	54	-	99	63	-
15	48	30	0.17	61	32	-	70	50	-	77	48	-	90	59	-	102	68	-
16	54	39	-	54	34	-	63	41	-	75	46	-	84	52	-	102	68	-
17	54	32	-	64	36	-	64	41	-	73	46	-	82	55	-	95	68	-
18	54	37	-	61	36	-	70	36	-	73	45	-	86	57	-	97	66	-
19	55	36	-	63	37	-	61	48	-	81	45	-	90	57	-	99	64	-
20	57	37	-	64	43	-	70	45	-	79	48	-	95	59	-	97	66	-
21	55	36	-	61	41	-	66	48	-	82	45	-	99	55	-	97	66	-
22	54	28	-	59	37	-	70	41	-	72	55	-	97	59	-	99	64	-
23	54	28	-	61	37	-	72	36	-	77	50	-	91	61	-	100	66	-
24	48	34	-	63	39	-	75	37	-	86	66	-	97	64	0.04	100	61	-
25	54	28	-	64	37	-	77	37	-	88	52	-	100	59	-	106	61	-
26	54	30	-	63	39	0.05	82	34	-	66	48	-	102	61	-	91	64	-
27	48	28	0.09	66	34	-	81	39	-	95	48	-	86	64	-	95	64	-
28	57	30	-	64	37	-	77	45	-	97	61	-	97	63	-	102	68	-
29	54	34	-	-	-	-	79	50	-	93	54	-	95	68	-	102	66	-
30	57	34	-	-	-	-	77	55	0.07	95	55	-	99	66	-	106	63	-
31	55	32	-	-	-	-	77	48	-	-	-	-	102	68	-	-	-	-

SHADE TEMPERATURE (FAHRENHEIT) AND RAINFALL AT OAK RIDGE, TENN. FOR 1935 (CONT'D)

Table A-3

Date	July			August			September			October			November			December		
	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall
1	104	68	-	104	68	-	109	72	-	73	48	-	68	52	-	57	45	-
2	102	70	-	100	64	-	108	72	-	84	50	-	66	54	-	59	39	-
3	102	73	-	100	70	-	108	70	-	86	50	-	58	48	-	63	37	-
4	95	66	-	106	70	-	109	66	-	86	61	-	72	43	-	65	39	-
5	99	68	-	106	68	-	95	66	-	95	52	-	58	50	0.06	61	46	-
6	104	70	-	104	72	-	95	68	-	86	63	-	73	50	-	65	41	-
7	108	73	-	104	72	-	102	68	-	86	55	-	70	50	0.08	63	46	-
8	108	72	-	102	70	-	102	68	-	86	63	0.01	72	46	-	64	46	-
9	102	66	-	104	68	-	102	68	-	81	61	0.25	70	48	0.01	63	43	-
10	99	77	-	99	72	-	102	66	-	79	57	0.04	68	50	0.06	64	36	0.31
11	91	64	-	95	66	-	106	63	-	79	55	-	72	48	-	61	43	-
12	95	68	-	95	64	-	97	68	-	82	55	-	70	49	-	57	41	-
13	95	66	-	99	68	-	100	64	-	90	61	0.14	66	46	-	63	41	-
14	99	64	-	100	68	-	102	66	-	88	59	0.06	63	46	-	64	37	-
15	100	64	-	100	70	-	102	68	-	82	55	-	59	45	0.10	59	37	0.02
16	104	68	-	100	70	-	95	68	-	82	57	-	57	46	0.11	48	41	-
17	109	70	-	106	68	-	95	63	-	84	57	0.02	59	48	-	54	41	-
18	106	68	-	109	64	-	104	68	-	86	55	-	63	45	-	57	36	-
19	108	70	-	113	68	-	102	61	-	72	57	0.94	57	39	-	61	36	-
20	108	70	-	106	72	-	100	61	-	82	57	0.39	59	34	0.05	55	37	-
21	108	70	-	102	64	-	100	63	-	74	57	0.10	59	43	0.02	55	37	-
22	108	70	-	106	64	-	102	61	-	77	55	-	55	36	-	57	39	-
23	104	72	-	104	64	-	100	61	-	77	57	-	59	36	-	59	39	-
24	106	72	-	102	70	-	102	61	-	82	54	-	61	30	-	59	36	-
25	102	70	-	102	70	-	97	64	-	82	54	-	59	32	0.03	59	36	-
26	104	68	-	104	68	-	91	59	-	84	52	-	57	37	-	58	39	0.07
27	108	70	-	108	64	-	91	61	-	79	55	-	59	32	-	55	49	-
28	104	72	-	114	64	-	90	55	-	77	57	-	50	41	0.03	57	37	0.04
29	104	72	-	108	70	-	81	59	-	77	54	-	54	48	0.06	59	41	0.08
30	102	66	-	106	70	-	79	50	-	77	53	-	55	50	0.48	54	41	-
31	100	64	-	108	68	-	-	-	-	70	52	0.03	-	-	-	54	32	-

SHADE TEMPERATURE (FAHRENHEIT) AND AMOUNT OF RAINFALL FOR 1938 (Cont'd) Sheet No 3

Date	July			August			September			October			November			December		
	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall
1	108	72	-	109	77	-	104	70	-	64	50	-	88	52	-	68	34	-
2	106	70	-	106	73	-	108	72	-	70	48	-	86	63	-	66	37	-
3	100	68	0.05	108	73	-	104	70	-	82	50	-	82	55	-	66	37	-
4	104	72	-	104	72	-	106	72	-	86	50	-	77	59	0.10	64	37	-
5	104	70	-	104	72	-	106	70	-	84	52	-	72	48	0.04	68	34	-
6	106	72	-	102	70	-	104	70	-	86	52	-	66	48	-	66	34	-
7	108	73	-	106	72	-	100	70	-	86	52	-	64	45	0.20	52	36	0.53
8	112	70	-	104	73	-	102	68	-	86	50	-	66	41	-	64	41	-
9	109	77	-	102	72	-	100	66	-	86	52	-	63	43	0.06	54	43	0.04
10	108	72	-	100	70	-	100	66	-	84	52	-	64	45	-	63	34	-
11	110	70	-	104	68	-	100	68	-	82	48	-	68	34	-	57	37	-
12	109	77	-	104	66	-	100	64	-	84	46	-	66	27	-	59	39	0.05
13	108	75	-	102	66	-	100	66	-	81	45	-	64	23	-	50	39	0.25
14	112	77	-	106	66	-	98	64	-	84	48	-	64	25	-	55	39	0.03
15	109	77	-	104	68	-	99	65	-	81	45	-	68	27	-	54	34	-
16	106	75	-	109	73	-	97	63	-	81	48	-	66	28	-	52	34	0.05
17	108	77	-	104	70	-	97	63	-	79	46	-	68	34	-	50	41	-
18	108	77	-	106	70	-	100	65	-	81	48	-	68	32	-	59	34	-
19	109	79	-	106	68	-	91	59	-	79	45	-	68	32	-	59	34	-
20	99	68	-	104	68	-	90	61	-	81	50	-	68	32	-	55	34	-
21	99	68	-	104	66	-	91	59	-	84	48	-	66	34	-	60	30	-
22	100	68	-	106	64	-	88	57	-	82	46	-	66	34	-	59	32	-
23	104	68	-	102	66	-	86	57	-	79	50	-	64	37	-	55	30	-
24	104	70	-	100	70	-	84	55	-	79	46	-	70	36	-	54	28	-
25	106	72	-	104	73	-	86	57	-	78	45	-	68	40	-	55	34	-
26	104	72	-	104	72	-	84	57	-	77	46	-	57	39	-	55	32	-
27	109	72	-	106	70	-	86	54	-	78	46	-	68	37	-	63	34	-
28	109	72	-	102	70	-	82	57	-	79	46	-	66	39	-	59	34	0.38
29	109	72	-	102	70	-	59	41	-	81	48	-	63	43	-	55	36	0.34
30	108	73	-	102	72	-	61	45	-	82	50	-	66	41	-	55	34	-
31	108	73	-	102	72	-	-	-	-	84	52	-	-	-	-	-	-	-

SHADE TEMPERATURE (PHILADELPHIA) AND RAINFALL FOR 1926.

Syria

Date	July			August			September			October			November			December		
	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall
1	97	64	-	100	72	-	95	68	-	93	55	-	90	45	-	63	43	0.01
2	99	66	-	102	73	-	93	66	-	97	57	-	86	46	-	55	39	0.30
3	100	64	-	104	77	-	93	68	-	93	63	-	86	46	-	63	39	-
4	99	70	-	106	75	-	93	64	-	91	54	-	79	54	-	63	37	-
5	100	70	-	111	73	-	100	68	-	86	61	-	79	40	-	63	30	-
6	100	70	-	111	73	-	97	66	-	81	54	-	79	45	-	64	37	-
7	91	68	-	111	81	-	99	63	-	82	55	-	77	50	-	57	34	-
8	95	68	-	108	90	-	99	66	-	86	48	-	79	45	-	54	28	-
9	99	68	-	113	77	-	91	61	-	97	48	-	75	52	0.01	55	27	-
10	104	68	-	115	79	-	90	59	-	92	57	-	61	48	0.04	54	30	-
11	104	68	-	106	77	-	91	66	-	86	54	-	75	43	-	52	25	-
12	108	73	-	100	70	-	91	66	-	82	52	-	75	41	-	57	23	-
13	104	72	-	106	68	-	93	59	-	88	54	-	77	41	-	54	21	-
14	106	75	-	109	72	-	91	57	-	88	52	-	77	39	-	50	18	-
15	108	73	-	109	75	-	90	64	-	95	54	-	72	37	-	55	19	-
16	109	72	-	108	75	-	88	57	-	93	55	-	75	36	-	50	21	-
17	104	75	-	109	73	-	86	61	-	88	55	-	77	37	-	48	28	-
18	102	72	-	111	77	-	86	52	-	88	52	-	70	39	-	52	32	-
19	108	73	-	111	75	-	86	50	-	89	50	-	72	43	-	55	37	0.73
20	104	72	-	117	77	-	82	48	-	90	50	-	68	43	-	45	41	0.91
21	102	73	-	115	77	-	84	50	-	95	52	-	72	41	-	46	37	0.66
22	102	72	-	106	75	-	88	48	-	93	54	-	68	48	-	57	34	-
23	99	72	-	108	72	-	91	50	-	91	55	-	66	41	-	59	34	-
24	100	70	-	108	70	-	95	48	-	90	55	-	63	46	0.11	55	39	-
25	100	66	-	100	68	-	95	50	-	81	46	-	57	48	0.37	55	39	0.12
26	100	68	-	102	70	-	86	59	-	81	54	-	59	37	-	50	37	0.01
27	102	68	-	100	72	-	86	52	-	84	55	-	57	36	-	52	43	-
28	100	72	-	100	66	-	86	50	-	81	48	-	57	39	-	39	36	-
29	100	72	-	99	68	-	88	50	-	75	57	-	59	41	-	41	32	-
30	106	75	0.01	95	68	-	86	50	-	81	52	-	57	41	-	43	30	0.16
31	102	73	-	95	66	-	-	-	-	80	50	-	-	-	-	39	25	-

SHADE TEMPERATURES (PART SHEET) AND MEASUREMENT OF RAINFALL FOR 1937 (Cont'd.)

Syria.

T-3

Date	July Max.	July Min.	July Rain Fall	August Max.	August Min.	August Rain Fall	September Max.	September Min.	September Rain Fall	October Max.	October Min.	October Rain Fall	November Max.	November Min.	November Rain Fall	December Max.	December Min.	December Rain Fall
1	97	72	-	99	70	-	100	68	-	93	55	-	72	50	0.13	63	45	-
2	100	73	-	100	73	-	95	66	-	90	57	-	70	54	-	59	45	-
3	106	73	-	102	75	-	95	68	-	86	59	-	75	52	-	59	32	-
4	95	64	-	102	70	-	102	64	-	86	57	-	68	50	-	59	32	-
5	99	68	-	100	72	-	103	68	-	82	59	-	66	50	-	57	36	-
6	100	68	-	102	70	-	97	66	-	86	59	-	70	52	-	55	34	-
7	99	70	-	104	75	-	97	68	-	90	54	-	72	48	-	59	32	-
8	106	72	-	106	75	-	95	68	-	91	52	-	70	52	-	59	32	-
9	106	73	-	100	66	-	95	68	-	95	55	-	68	52	-	59	32	-
10	106	72	-	99	70	-	99	64	-	95	61	-	66	54	-	63	32	-
11	104	72	-	100	70	-	100	72	-	95	61	-	66	55	-	63	30	-
12	104	70	-	106	72	-	100	72	-	90	50	-	68	55	-	61	28	-
13	104	68	-	102	70	-	100	68	-	93	55	-	75	55	0.08	59	27	-
14	104	72	-	104	73	-	100	68	-	91	54	-	63	52	0.06	66	28	-
15	104	68	-	100	68	-	104	68	-	88	59	0.01	70	48	-	63	36	-
16	97	66	-	100	70	-	102	64	-	78	46	-	70	48	-	61	36	-
17	100	66	-	102	70	-	100	64	-	77	50	-	68	50	0.42	57	36	-
18	100	70	-	104	68	-	97	61	-	86	50	-	66	55	0.01	64	34	-
19	108	73	-	102	72	-	102	64	-	84	52	-	64	48	-	68	36	-
20	111	75	-	102	68	-	104	66	-	88	57	0.13	63	54	0.01	64	41	-
21	111	75	-	99	66	-	104	68	-	77	54	-	63	52	0.08	64	46	-
22	108	73	-	97	66	-	102	64	-	73	59	-	68	46	-	59	48	-
23	104	68	-	97	64	-	104	66	-	79	52	-	68	50	-	63	39	-
24	102	73	-	97	68	-	107	61	-	75	55	-	61	54	-	64	37	-
25	108	73	-	97	68	-	106	61	-	73	54	-	64	46	-	63	45	0.35
26	114	79	-	97	66	-	108	59	-	75	55	-	68	48	0.02	64	39	-
27	108	77	-	93	64	-	100	64	-	70	59	-	66	50	0.15	55	32	-
28	104	75	-	95	68	-	95	65	-	72	55	0.05	59	46	0.05	55	30	-
29	106	72	-	99	70	-	90	59	-	64	57	0.20	66	45	-	61	28	-
30	108	73	-	100	68	-	90	57	-	68	54	-	59	45	-	61	28	-
31	106	72	-	100	70	-	-	-	-	72	54	-	-	-	-	63	30	-

SHADE TEMPERATURE (FAHRENHEIT) AND RAINFALL FOR 1936

1-3

Date	January			February			March			April			May			June		
	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall
1	54	30	-	52	39	0.41	68	34	-	84	43	-	81	50	-	90	59	-
2	54	30	-	57	46	-	72	39	-	70	43	-	86	55	-	93	65	-
3	48	30	-	57	37	-	70	37	-	72	50	-	91	57	-	95	64	-
4	48	34	-	61	37	-	66	43	-	74	41	-	91	63	-	93	64	-
5	54	36	-	63	39	-	70	41	-	75	46	-	97	55	-	86	61	-
6	57	32	0.02	59	39	0.03	66	34	-	68	48	-	86	64	-	93	64	-
7	50	39	0.03	62	37	-	70	41	-	73	52	-	86	54	-	95	68	-
8	54	42	-	64	36	-	70	34	0.15	75	50	-	88	57	-	86	64	-
9	59	36	-	59	39	-	70	41	0.05	88	48	-	90	55	0.02	84	61	-
10	59	34	-	61	46	0.02	70	41	0.22	88	52	-	95	57	-	86	63	-
11	54	32	-	55	37	-	55	37	0.32	93	52	-	86	61	-	95	64	-
12	54	43	0.13	45	43	0.01	61	39	-	97	54	-	81	57	0.52	99	68	-
13	55	41	-	50	39	0.05	66	37	-	93	52	-	84	54	-	93	66	-
14	57	37	0.06	46	32	-	68	37	-	81	55	-	81	55	-	88	61	-
15	50	46	-	55	30	-	73	36	-	81	48	-	81	55	-	91	63	-
16	52	41	0.03	54	28	-	73	46	-	81	50	-	81	57	-	90	61	-
17	52	37	0.04	55	37	0.05	70	48	-	79	52	-	79	54	-	86	61	-
18	82	41	-	54	39	-	70	39	-	88	52	-	82	52	-	91	61	-
19	57	37	-	57	32	-	75	43	-	95	54	-	84	54	-	95	64	-
20	59	41	0.08	64	41	-	77	43	-	77	55	-	81	55	-	100	64	-
21	61	43	-	64	43	0.15	73	41	0.04	86	55	-	86	52	-	109	63	-
22	61	39	-	57	46	0.04	59	41	-	95	48	-	91	55	-	104	73	-
23	64	36	-	54	39	0.05	55	32	-	102	59	-	99	61	-	100	66	-
24	61	37	-	57	39	-	68	28	-	97	61	-	100	63	-	100	64	-
25	61	37	-	64	43	-	72	30	-	84	61	-	95	68	-	95	66	-
26	63	41	0.06	66	43	0.08	77	37	-	77	48	-	95	55	-	95	64	-
27	63	37	-	63	48	-	81	46	-	90	48	-	84	57	-	95	61	-
28	68	36	-	63	39	-	81	46	-	84	55	-	95	55	-	95	63	-
29	59	36	0.01	64	39	-	82	45	-	75	48	-	93	57	-	97	64	-
30	59	41	0.03	-	-	-	82	45	-	75	54	-	81	57	-	100	63	-
31	61	41	-	-	-	-	81	45	-	-	-	-	91	59	-	-	-	-

SHADE TEMPERATURE (FAHRENHEIT) AND RAINFALL AT OBSERVATORY FOR 1937.

Syria

T-3

Date	January			February			March			April			May			June		
	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall
1	43	25	-	52	34	0.05	66	36	-	79	43	-	95	63	-	86	59	-
2	43	25	-	48	30	-	70	39	-	81	50	-	97	68	-	82	57	-
3	46	27	-	45	30	-	64	43	-	72	57	0.03	93	61	-	81	55	-
4	41	28	-	45	32	-	63	50	0.08	59	50	0.12	90	66	-	88	59	-
5	37	32	-	48	34	-	63	41	-	73	48	-	90	59	-	95	64	-
6	36	28	0.10	57	32	-	68	36	-	77	48	-	84	73	-	99	61	-
7	45	28	-	63	37	-	70	43	-	75	46	-	90	55	-	102	66	-
8	46	27	-	59	34	-	66	34	-	75	57	-	79	52	-	91	63	-
9	50	28	-	61	41	-	72	43	-	86	61	0.08	79	54	-	93	59	-
10	48	30	-	66	41	-	73	41	-	55	52	0.60	79	54	-	99	64	-
11	48	30	-	72	37	-	77	41	-	55	48	-	79	54	-	99	66	-
12	50	32	0.03	68	39	-	77	41	-	70	50	-	77	50	-	95	64	-
13	50	34	-	68	39	-	75	41	-	77	52	-	77	52	-	93	61	-
14	50	32	-	64	37	-	79	48	-	81	54	-	81	52	-	97	64	-
15	48	36	-	64	41	-	86	45	-	88	54	-	90	63	-	100	68	-
16	46	34	0.01	55	41	-	86	45	-	88	68	-	91	57	0.11	102	70	-
17	52	36	-	55	41	-	84	46	-	77	48	0.63	90	64	0.03	104	73	-
18	54	37	0.01	61	43	-	73	46	-	73	50	-	75	57	0.04	100	68	-
19	39	37	0.03	63	37	-	70	48	-	73	50	-	81	52	-	100	68	-
20	43	41	-	66	39	-	79	52	-	77	54	-	84	59	-	99	66	-
21	55	41	0.06	64	46	0.04	84	48	-	84	57	-	86	55	0.10	97	68	-
22	52	39	-	63	48	-	88	45	-	91	61	-	81	59	-	97	66	-
23	48	34	-	64	43	-	86	43	-	93	57	-	88	61	-	97	64	-
24	48	32	0.01	64	43	-	86	45	-	88	55	-	91	64	-	93	64	-
25	39	30	-	66	34	-	88	48	-	86	55	-	93	64	-	91	66	-
26	41	27	0.02	61	39	-	90	48	-	91	54	-	97	64	-	95	66	-
27	43	30	-	63	37	-	90	52	-	97	64	-	97	65	-	97	66	-
28	46	34	-	66	37	-	73	50	-	97	64	-	95	64	-	95	64	-
29	48	37	-	-	-	-	72	48	-	97	68	-	99	61	-	93	68	-
30	46	39	0.05	-	-	-	72	45	-	95	66	-	97	64	-	97	70	-
31	59	45	0.60	-	-	-	77	45	-	-	-	-	95	61	-	-	-	-

SHOWING TEMPERATURE (FAHRENHEIT) AND MEASUREMENT OF RAINFALL
FOR 1938
Syria

Date	January			February			March			April			May			June		
	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall
1	63	41	=	59	34	0.04	50	28	=	72	46	=	97	59	=	93	61	=
2	55	37	=	59	43	0.02	55	32	0.05	73	50	=	91	63	=	95	59	=
3	46	39	=	57	37	=	50	28	=	73	50	=	95	61	=	91	63	=
4	54	39	0.12	59	39	=	55	34	=	77	48	=	86	57	=	95	61	=
5	59	48	=	57	37	=	55	34	=	75	52	=	93	63	=	97	63	=
6	54	43	0.01	55	37	0.12	59	39	0.10	73	52	=	86	55	=	97	61	=
7	50	43	=	54	36	=	54	34	=	79	50	=	90	54	=	102	64	=
8	48	46	=	50	36	=	59	37	=	72	50	=	91	59	=	100	63	=
9	57	41	0.02	52	37	0.10	59	37	=	68	48	=	95	61	=	104	64	=
10	54	36	=	41	30	=	60	34	=	72	46	=	93	57	=	102	63	=
11	54	39	=	46	36	=	68	39	=	75	46	=	97	59	=	100	64	=
12	50	32	=	50	34	=	68	43	=	77	50	=	93	59	=	100	66	=
13	48	39	0.15	54	36	=	66	41	=	79	52	=	97	61	=	97	64	=
14	54	46	=	59	36	=	66	39	=	70	43	=	93	57	=	98	64	=
15	50	32	0.40	59	34	=	63	41	0.37	75	50	=	90	52	=	95	59	=
16	48	34	0.10	63	36	=	52	39	=	72	48	=	91	54	=	100	63	=
17	48	34	0.11	61	37	=	59	41	=	72	48	=	93	57	=	102	61	=
18	48	46	0.20	57	37	=	59	39	=	75	52	=	97	59	=	100	66	=
19	48	37	0.29	61	39	=	59	34	=	70	48	=	95	59	=	100	64	=
20	50	48	0.04	63	43	=	61	36	=	82	54	=	97	59	=	100	66	=
21	54	43	=	59	41	=	72	39	=	80	54	=	97	61	=	102	64	=
22	50	43	0.07	54	45	0.17	64	45	=	97	54	=	97	64	=	100	64	=
23	50	45	=	54	39	=	73	41	=	97	57	=	100	63	=	102	66	=
24	48	37	0.11	55	37	0.02	77	46	0.03	92	54	=	102	63	=	106	73	=
25	46	43	=	54	41	=	68	46	0.20	91	59	0.02	102	64	=	106	72	=
26	48	37	0.07	57	27	=	68	45	0.07	90	61	=	100	64	=	104	72	=
27	48	43	0.01	41	27	=	70	48	=	88	57	=	97	59	=	111	70	=
28	52	34	=	46	32	=	73	52	0.03	91	57	=	93	59	=	108	72	=
29	55	32	=	=	=	=	70	50	=	93	59	=	95	61	=	106	72	=
30	46	37	0.12	=	=	=	66	39	=	95	61	=	91	63	=	108	73	=
31	52	37	=	=	=	=	70	45	=	=	=	=	95	63	=	=	=	=

SHADE TEMPERATURE (FAHRENHEIT) AND MEASUREMENT OF RAINFALL FOR 1932

T-4

Date	January			February			March			April			May			June		
	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall
1	54	40	=	48	36	=	64	40	=	72	44	=	100	59	=	103	68	=
2	54	40	=	52	35	0.65	64	40	=	72	56	=	102	63	=	103	63	=
3	54	40	0.15	50	39	=	68	39	=	66	45	=	100	63	=	104	63	=
4	53	41	=	41	37	0.65	68	45	=	65	36	=	95	63	=	105	65	=
5	54	39	0.20	45	32	=	64	38	=	67	36	=	90	55	=	104	59	=
6	52	43	=	51	35	=	64	37	=	72	41	=	86	45	=	104	59	=
7	51	43	=	50	35	=	63	38	=	80	43	=	83	55	0.03	100	57	=
8	46	40	=	56	34	=	64	37	=	82	47	=	83	55	=	100	63	=
9	50	41	=	58	36	=	70	44	=	80	61	0.03	86	45	=	102	63	=
10	48	36	=	59	43	=	72	45	=	72	51	0.03	93	50	=	106	68	=
11	44	29	=	63	45	0.13	72	46	=	63	49	0.04	94	57	=	102	72	=
12	41	25	=	63	46	=	67	41	=	63	48	0.02	88	68	=	99	66	=
13	43	33	=	66	50	0.25	70	38	=	65	47	0.16	90	55	=	95	61	=
14	45	34	=	66	50	0.35	71	37	=	72	47	=	97	55	=	97	61	=
15	45	36	0.30	53	38	0.04	70	50	=	72	46	=	90	55	=	96	58	=
16	52	36	=	55	36	=	64	45	0.06	73	41	=	86	54	=	97	68	=
17	58	40	=	55	40	=	59	43	=	73	44	=	82	54	=	95	60	=
18	48	41	0.03	59	38	=	66	39	=	67	46	=	86	55	=	95	58	=
19	51	36	0.03	61	37	=	70	49	=	79	39	=	97	55	=	97	60	=
20	54	38	=	59	42	0.05	72	44	=	78	46	=	93	57	=	95	62	=
21	53	37	=	58	40	=	64	46	=	72	53	0.05	95	61	=	93	59	=
22	50	36	=	57	36	=	71	36	=	71	46	=	95	64	=	96	61	=
23	53	39	=	58	36	=	72	40	=	71	45	=	91	64	=	96	63	=
24	54	35	0.02	61	38	=	73	56	=	82	43	=	95	57	=	95	64	=
25	50	38	=	63	35	=	75	56	=	84	50	=	99	64	=	92	65	=
26	53	38	=	62	38	=	81	63	=	86	46	=	100	61	=	90	62	=
27	56	36	0.12	64	39	=	79	64	=	93	54	=	102	66	=	99	60	=
28	53	37	=	68	40	=	76	63	=	93	63	=	99	57	=	100	65	=
29	55	37	=	-	-	=	76	58	=	93	54	=	95	63	=	103	62	=
30	53	36	0.05	-	-	=	74	56	=	97	57	=	99	63	=	100	62	=
31	53	35	0.05	-	-	=	75	59	=	-	-	=	102	68	=	-	-	=

Date	July			August			September			October			November			December		
	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall
1	100	64	-	95	60	-	106	64	-	79	48	-	79	47	-	58	45	-
2	99	68	-	95	63	-	108	65	-	79	48	-	65	50	-	57	43	-
3	95	64	-	96	65	-	102	66	-	84	53	-	66	45	-	64	44	-
4	92	63	-	102	65	-	95	64	-	84	64	-	67	48	-	64	40	-
5	98	63	-	102	65	-	92	63	-	79	58	-	72	50	-	60	45	-
6	101	64	-	100	68	-	94	79	-	89	55	-	71	47	-	63	46	-
7	105	65	-	100	66	-	99	63	-	84	53	-	71	49	0.50	64	45	-
8	104	68	-	100	68	-	95	63	-	88	54	-	72	55	0.37	63	41	-
9	100	64	-	102	66	-	97	57	-	84	64	0.10	71	45	0.03	62	43	-
10	94	67	-	99	68	-	97	63	-	79	55	0.05	70	52	-	63	39	0.30
11	90	66	-	90	63	-	100	66	-	76	54	-	66	46	-	61	43	-
12	95	66	-	91	63	-	95	63	-	81	54	-	67	45	-	59	39	-
13	100	65	-	97	63	-	99	61	-	88	63	0.33	65	45	-	58	40	-
14	98	61	-	99	64	-	100	54	-	82	63	0.16	65	50	-	58	39	-
15	95	61	-	99	68	-	104	57	-	82	54	-	58	45	0.07	57	36	-
16	100	65	-	100	68	-	100	61	-	81	53	-	58	45	-	57	37	0.02
17	104	66	-	106	68	-	95	63	-	84	63	0.03	63	48	-	56	45	-
18	102	63	-	108	65	-	100	57	-	88	54	-	59	45	-	56	36	0.02
19	102	63	-	111	77	-	99	63	-	79	57	0.08	63	36	-	59	36	-
20	106	65	-	102	68	-	98	64	-	79	53	0.40	64	36	0.15	53	40	-
21	106	66	-	102	65	-	98	61	-	73	54	-	59	49	0.05	56	45	0.02
22	104	65	-	106	66	-	100	57	-	77	59	-	59	36	-	54	36	-
23	101	65	-	104	65	-	100	61	-	77	50	-	58	37	-	59	37	-
24	102	66	-	100	63	-	99	56	-	79	50	-	58	38	-	58	36	-
25	102	64	-	100	61	-	90	59	-	83	50	-	57	35	-	57	40	-
26	102	65	-	102	65	-	97	61	-	84	55	-	55	37	-	56	38	0.45
27	100	66	-	106	66	-	88	59	-	85	50	-	55	36	-	54	43	-
28	100	68	-	110	75	-	88	61	-	75	54	-	55	43	0.03	58	38	0.10
29	99	65	-	108	68	-	84	61	-	75	61	-	53	46	0.02	61	43	0.10
30	99	64	-	106	72	-	75	50	-	73	54	-	57	48	0.30	55	37	-
31	99	63	-	105	63	-	-	-	-	73	53	-	-	-	-	54	34	-

SHADE TEMPERATURE (FAHRENHEIT) AND AMOUNT OF RAINFALL FOR 1936

T-4

SYRIA

Date	January Max.	January Min.	January Rain Fall	February Max.	February Min.	February Rain Fall	March Max.	March Min.	March Rain Fall	April Max.	April Min.	April Rain Fall	May Max.	May Min.	May Rain Fall	June Max.	June Min.	June Rain Fall
1	52	30	-	63	44	0.30	68	45	-	65	41	-	73	49	-	89	52	-
2	48	34	-	61	44	0.01	67	46	-	68	43	-	83	50	-	92	54	-
3	50	35	-	58	43	-	68	45	-	68	43	-	86	54	-	94	54	-
4	46	36	-	62	37	-	68	44	-	72	43	-	85	58	-	84	61	-
5	54	35	-	61	44	-	68	40	-	72	40	-	91	61	-	83	73	-
6	50	36	-	60	36	-	65	36	-	74	41	0.05	88	53	-	90	61	-
7	52	45	-	62	37	-	68	46	-	72	50	0.20	82	46	-	92	77	-
8	58	45	-	63	43	-	64	37	0.07	72	46	-	82	49	-	82	57	-
9	63	36	-	61	37	-	56	38	0.05	83	44	-	85	57	-	82	50	-
10	63	36	-	59	43	0.10	59	41	0.20	84	53	-	90	57	-	88	62	-
11	53	36	-	52	37	-	56	43	0.25	90	54	-	82	55	-	97	55	-
12	50	38	0.04	54	41	0.05	62	36	-	94	59	-	88	57	0.04	93	73	-
13	53	38	-	55	45	0.15	66	34	-	84	62	-	81	58	-	90	61	-
14	61	36	-	46	28	-	68	36	-	73	49	-	80	50	-	84	55	-
15	57	44	0.01	54	30	-	73	54	-	79	53	-	80	47	-	88	54	-
16	54	46	-	52	34	-	70	46	-	73	46	-	74	57	0.20	82	54	-
17	54	40	-	52	39	-	65	44	-	77	53	-	75	52	-	85	61	-
18	55	41	-	52	34	-	70	44	-	85	45	-	81	50	-	90	55	-
19	58	41	0.05	55	36	-	72	40	-	88	63	-	86	50	-	95	57	-
20	63	39	0.03	63	38	-	75	41	-	74	53	-	79	55	-	102	61	-
21	59	45	-	62	40	0.22	65	47	0.20	77	58	-	86	50	-	108	75	-
22	59	45	-	52	50	-	61	38	-	89	53	-	88	54	-	100	61	-
23	64	35	-	52	38	0.02	62	30	-	98	65	-	97	56	-	95	68	-
24	62	36	-	58	36	-	65	35	-	91	59	-	98	65	-	97	64	-
25	61	36	-	62	41	-	70	34	-	90	63	-	90	61	-	92	73	-
26	63	39	-	63	38	-	72	45	-	81	45	-	90	57	-	91	61	-
27	63	39	-	63	48	-	77	50	-	88	50	-	81	55	-	98	59	-
28	65	37	-	63	36	-	76	45	-	88	56	-	85	55	-	92	59	-
29	61	45	0.01	65	36	-	79	45	-	73	61	0.10	90	77	-	90	61	-
30	56	36	0.05	-	-	-	79	45	-	72	50	-	77	55	-	91	62	-
31	61	39	-	-	-	-	75	50	-	-	-	-	85	54	-	-	-	-

SHADE TEMPERATURE (FAHRENHEIT) AND MEASUREMENT OF RAINFALL FOR 1925 (Cont'd)

T-4

SYRIA

Date:	July			August			September			October			November			December		
	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall
1	93	57	-	100	66	-	93	68	-	90	54	-	84	46	-	55	43	0.12
2	94	60	-	101	67	-	90	64	-	91	55	-	83	60	-	52	46	0.32
3	93	61	-	100	72	-	91	61	-	91	57	-	84	45	-	55	45	-
4	97	81	-	103	72	-	95	64	-	91	57	-	80	55	-	61	43	-
5	99	65	-	106	66	-	95	61	-	88	68	-	78	50	-	62	41	-
6	94	63	-	111	72	-	97	57	-	79	57	-	75	48	-	60	43	-
7	88	73	-	109	75	-	95	62	-	80	50	-	75	46	-	56	39	-
8	92	68	-	109	83	-	93	64	-	88	50	-	79	52	-	54	34	-
9	94	64	-	111	83	-	88	63	-	95	48	-	81	54	-	55	30	-
10	100	63	-	111	81	-	88	63	-	92	55	-	72	50	-	54	27	-
11	99	73	-	104	72	-	90	61	-	82	54	-	73	45	-	50	27	-
12	104	73	-	93	64	-	90	61	-	84	47	-	75	44	-	52	24	-
13	99	82	-	103	61	-	90	61	-	86	50	-	78	45	-	46	24	-
14	101	72	-	108	68	-	88	59	-	88	50	-	81	45	-	42	21	-
15	108	64	-	102	64	-	88	63	-	95	55	-	72	44	-	45	20	-
16	105	62	-	104	65	-	86	58	-	91	55	-	71	41	-	46	18	-
17	103	66	-	106	81	-	84	55	-	88	54	-	72	41	-	45	21	-
18	100	68	-	106	68	-	84	54	-	86	54	-	72	41	-	50	34	-
19	102	66	-	106	73	-	83	48	-	84	50	-	71	43	-	55	33	0.45
20	102	68	-	109	68	-	79	50	-	95	50	-	72	48	0.02	50	38	0.23
21	99	65	-	111	68	-	82	39	-	99	55	-	64	46	-	45	41	0.18
22	97	70	-	102	68	-	84	48	-	97	54	-	66	44	0.01	54	37	-
23	99	64	-	103	70	-	88	50	-	93	63	-	64	48	0.02	59	36	-
24	99	61	-	102	63	-	95	55	-	91	59	-	61	39	0.30	61	37	0.05
25	98	63	-	101	63	-	91	54	-	86	55	-	57	44	0.15	55	36	-
26	97	63	-	100	66	-	91	57	-	81	50	-	55	50	-	48	41	0.03
27	92	66	-	99	61	-	88	50	-	82	52	-	57	33	-	54	41	-
28	89	68	-	97	65	-	83	54	-	80	54	0.15	55	35	-	48	38	0.05
29	97	68	-	93	61	-	84	53	-	74	60	-	55	36	-	39	32	-
30	100	71	-	92	63	-	86	52	-	78	54	-	55	36	-	46	28	0.03
31	100	68	-	91	63	-	-	-	-	81	59	-	-	-	-	45	25	-

SHADE TEMPERATURE (FAHRENHEIT) AND RAINFALL OF BULAWAYO FOR 1937

T-4

SYRIA

Date	January Max.	January Min.	January Rain Fall	February Max.	February Min.	February Rain Fall	March Max.	March Min.	March Rain Fall	April Max.	April Min.	April Rain Fall	May Max.	May Min.	May Rain Fall	June Max.	June Min.	June Rain Fall
1	43	19	-	54	41	0.03	66	37	-	79	39	-	93	55	-	84	61	-
2	38	19	-	50	32	-	70	37	-	79	54	-	99	65	-	81	55	0.02
3	41	19	-	45	32	-	63	41	-	75	55	0.05	95	72	-	81	59	-
4	39	25	-	46	30	-	68	43	0.03	68	59	-	86	61	-	86	55	-
5	41	19	-	48	34	-	61	45	-	73	46	-	89	57	-	95	57	-
6	37	28	-	61	32	-	64	36	-	75	45	-	84	81	-	97	57	-
7	46	23	-	61	36	-	66	39	-	73	54	-	82	64	-	99	61	-
8	48	24	-	63	36	-	68	43	-	75	45	-	75	50	-	92	64	-
9	48	23	-	63	43	-	72	37	-	82	61	0.11	75	52	-	92	59	-
10	50	30	-	63	39	-	72	41	-	81	55	0.22	75	50	-	95	57	-
11	45	29	-	70	46	-	72	43	-	66	55	0.03	74	48	-	93	57	-
12	51	32	-	64	37	-	73	39	-	68	45	-	77	46	0.06	91	59	-
13	50	32	-	64	36	-	73	41	-	78	45	-	73	47	-	91	57	-
14	50	32	-	63	41	-	78	45	-	81	46	-	79	46	-	95	55	-
15	50	36	-	59	37	-	82	45	-	84	54	-	83	46	-	99	61	-
16	50	37	0.08	63	37	-	82	46	-	91	70	-	86	62	0.05	99	65	-
17	50	32	-	63	42	0.70	82	45	-	90	54	0.23	90	55	0.06	100	63	-
18	52	39	-	59	37	0.08	72	41	-	72	46	-	84	61	0.03	97	62	-
19	46	36	-	61	39	-	70	46	-	72	46	-	77	57	-	95	62	-
20	45	36	-	63	37	-	79	41	-	75	45	-	81	52	-	95	65	-
21	55	36	0.07	64	40	0.09	82	45	-	83	52	-	82	55	-	94	61	-
22	55	39	-	64	41	-	86	46	-	89	61	-	82	54	-	91	61	-
23	50	36	-	64	39	-	84	46	-	89	54	-	84	54	-	91	64	-
24	45	32	0.12	63	43	-	88	45	-	86	52	-	88	55	-	90	62	-
25	39	30	-	63	50	-	83	47	-	86	50	-	90	70	-	91	61	-
26	43	28	-	61	36	-	86	50	-	84	47	-	92	57	-	91	61	-
27	43	27	-	61	39	-	86	54	-	92	54	-	92	55	-	95	65	-
28	48	28	-	64	37	-	75	46	-	90	65	-	91	71	-	93	57	-
29	50	30	-	-	-	-	75	46	-	95	64	0.03	95	64	-	88	62	-
30	50	36	0.20	-	-	-	73	43	-	95	64	-	95	61	-	88	61	-
31	55	36	0.32	-	-	-	72	43	-	-	-	-	95	61	-	-	-	-

TABLE I. TEMPERATURE (FAHRENHEIT) AND RAINFALL OF ALEPPO FOR 1927 (cont'd)

T-4

SYRIA

Date	July Max.	July Min.	July Rain Fall	August Max.	August Min.	August Rain Fall	September Max.	September Min.	September Rain Fall	October Max.	October Min.	October Rain Fall	November Max.	November Min.	November Rain Fall	December Max.	December Min.	December Rain Fall
1	96	70	-	92	63	-	100	65	-	91	54	-	69	56	-	63	45	0.02
2	100	64	-	97	71	-	91	65	-	89	50	-	72	48	-	55	44	-
3	102	72	-	102	71	-	92	61	-	86	52	-	72	52	-	61	56	-
4	90	62	-	97	66	-	95	60	-	83	54	-	72	51	-	60	54	-
5	93	63	-	97	66	-	102	65	-	81	57	-	71	49	-	60	59	-
6	96	63	-	100	65	-	101	62	-	82	54	-	72	48	-	54	39	-
7	95	63	-	102	62	-	90	63	-	83	54	-	72	54	-	55	55	-
8	102	64	-	101	64	-	93	62	-	91	54	-	70	50	-	59	53	-
9	100	68	-	93	63	-	91	61	-	90	54	-	70	50	-	61	52	-
10	100	68	-	93	63	-	97	61	-	95	54	-	68	48	-	61	35	-
11	101	64	-	96	63	-	102	60	-	90	54	-	67	50	-	59	55	-
12	99	64	-	98	64	-	99	64	-	90	61	-	66	48	-	63	52	-
13	99	63	-	99	63	-	98	63	-	84	54	-	74	54	0.20	61	30	-
14	99	63	-	100	64	-	97	60	-	90	53	-	73	53	-	64	52	-
15	100	63	-	97	68	-	100	63	-	88	57	-	68	49	-	64	56	-
16	95	62	-	95	63	-	100	63	-	73	55	-	65	50	-	63	41	-
17	93	63	-	100	64	-	97	56	-	75	48	0.04	61	50	0.05	62	52	-
18	96	65	-	100	63	-	97	56	-	83	52	-	64	54	0.06	64	35	-
19	100	69	-	100	63	-	98	61	-	86	56	-	63	52	-	68	37	-
20	108	64	-	99	61	-	102	64	-	86	56	0.01	63	50	0.46	68	39	-
21	104	68	-	99	62	-	100	61	-	86	54	-	63	48	-	64	43	-
22	99	61	-	99	61	-	101	60	-	73	54	-	64	50	-	53	36	-
23	97	54	-	100	63	-	100	61	-	76	57	0.11	65	45	-	62	38	-
24	97	63	-	95	63	-	101	63	-	77	49	-	65	60	0.06	57	43	-
25	104	68	-	91	63	-	101	64	-	77	56	0.17	65	56	-	55	35	0.17
26	107	75	-	92	63	-	104	68	-	73	48	-	63	44	-	54	34	-
27	106	72	-	91	65	-	98	60	-	73	56	-	61	50	-	55	32	-
28	99	66	-	93	69	-	95	61	-	72	56	0.15	55	55	-	61	30	-
29	99	64	-	95	64	-	92	59	-	71	54	0.41	55	48	-	59	29	-
30	100	68	-	98	63	-	94	57	-	67	54	0.05	64	45	-	54	27	-
31	108	68	-	99	61	-	-	-	-	72	55	0.11	-	-	-	61	41	-

SHADE TEMPERATURE (FAHRENHEIT) AND RAINFALL OF RAIFFEISEN FOR 1928.

T-4 SYRIA

Date	January Max.	January Min.	January Rain Fall	February Max.	February Min.	February Rain Fall	March Max.	March Min.	March Rain Fall	April Max.	April Min.	April Rain Fall	May Max.	May Min.	May Rain Fall	June Max.	June Min.	June Rain Fall
1	62	41	0.11	57	36	-	50	23	-	65	36	-	84	50	-	90	61	-
2	59	45	"	59	36	-	50	28	0.05	64	36	-	81	51	-	91	55	-
3	52	37	-	57	37	"	49	35	0.11	70	40	"	72	69	"	90	54	-
4	50	34	0.27	63	36	"	49	29	"	71	44	"	73	46	"	90	54	-
5	59	43	"	61	36	-	55	35	"	82	53	"	72	50	"	90	54	-
6	59	43	0.05	61	37	0.15	54	35	0.15	81	56	-	81	45	"	94	56	-
7	53	36	"	55	37	"	54	36	"	74	57	-	86	61	"	95	56	-
8	54	44	"	54	36	"	58	30	"	71	45	-	89	55	"	95	59	-
9	55	37	"	55	36	0.08	58	36	"	61	43	"	90	54	"	98	61	-
10	55	30	0.05	48	32	"	60	38	"	70	40	"	90	55	"	97	62	-
11	56	36	"	45	24	"	64	35	"	71	44	"	86	53	"	96	56	-
12	54	35	"	53	32	"	64	36	"	80	45	-	91	54	"	89	60	-
13	50	39	0.10	52	33	"	62	36	"	80	57	-	82	54	"	87	61	-
14	50	39	"	55	35	"	60	35	"	70	59	-	74	49	"	90	61	-
15	53	28	0.50	60	36	"	56	38	0.15	69	45	-	78	46	"	93	64	-
16	50	36	"	57	36	"	50	36	-	71	60	-	74	50	"	97	61	-
17	53	34	0.15	57	33	"	55	36	"	66	56	-	73	49	"	90	56	-
18	50	39	"	59	36	"	55	36	"	72	54	"	72	45	"	88	56	-
19	46	36	0.25	61	36	-	56	40	0.05	81	50	"	84	46	"	90	57	-
20	50	39	"	61	37	"	61	29	"	87	50	"	86	50	"	94	57	-
21	50	34	"	59	36	"	65	35	"	91	55	"	95	55	"	97	58	-
22	50	39	"	64	43	0.10	63	40	"	91	55	"	94	62	"	95	61	-
23	48	37	"	61	41	"	70	45	"	93	56	"	98	62	"	97	55	-
24	50	39	0.25	54	33	"	70	40	"	81	52	"	99	61	"	101	63	-
25	53	40	0.05	56	39	0.20	70	43	"	90	52	"	95	63	"	102	64	-
26	50	36	0.30	46	35	"	68	41	"	90	52	"	81	52	"	104	64	-
27	48	37	"	48	34	"	71	42	"	94	62	"	84	56	"	106	63	-
28	53	38	"	59	33	"	71	46	"	90	54	"	83	50	"	104	63	-
29	52	32	"	-	-	-	72	43	"	87	69	"	84	53	"	95	59	-
30	54	37	0.05	-	-	-	64	42	"	81	50	"	86	53	"	95	67	-
31	54	36	"	-	-	-	55	35	"	-	-	-	87	54	-	-	-	-

SHADE TEMPERATURE (RAIN FALL) AT [illegible] FOR 1938. (Contd)

T-4

YRIA

Date:	July			August			September			October			November			December		
	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall	Max.	Min.	Rain Fall
1	100	64	-	106	67	-	104	65	-	84	45	-	82	61	0.02	66	39	-
2	100	64	-	106	66	-	107	65	-	84	48	-	81	56	-	65	37	-
3	95	67	-	102	71	-	103	64	-	85	50	-	81	62	0.17	64	48	-
4	98	64	-	106	68	-	102	70	-	90	51	-	70	54	0.50	65	37	-
5	99	63	-	102	65	-	102	63	-	88	48	-	69	57	0.20	61	37	-
6	97	65	-	102	63	-	97	69	-	85	56	-	69	55	0.05	60	38	0.10
7	104	68	-	103	62	-	99	64	-	83	53	-	65	45	0.15	54	45	0.10
8	106	72	-	101	67	-	96	62	-	85	50	-	58	51	-	62	36	-
9	107	72	-	99	61	-	94	63	-	86	54	-	58	43	0.05	55	45	-
10	107	71	-	99	66	-	93	63	-	82	53	-	61	44	-	57	38	-
11	106	68	0.04	98	66	-	97	83	-	79	55	-	62	36	-	57	39	-
12	103	76	-	98	66	-	99	62	-	79	47	-	63	37	-	61	45	-
13	103	71	-	93	74	-	100	65	-	80	47	-	63	31	-	57	36	-
14	106	65	-	99	66	-	95	62	-	81	46	-	62	28	-	55	36	-
15	103	65	-	105	70	-	95	62	-	87	50	-	62	31	-	55	36	0.05
16	97	66	-	107	65	-	93	63	-	88	54	0.02	61	31	-	53	30	-
17	97	63	-	99	62	-	88	61	-	81	54	-	62	34	-	50	37	-
18	93	71	-	99	63	-	88	63	-	81	50	-	64	43	-	57	36	-
19	93	64	-	101	61	-	86	63	-	82	51	-	66	35	-	55	36	-
20	95	65	-	102	62	-	84	59	-	84	61	-	66	35	-	55	45	-
21	95	63	-	99	66	-	85	58	-	82	59	-	65	36	-	56	32	-
22	97	63	-	97	66	-	83	55	-	78	50	-	60	36	-	61	32	-
23	97	63	-	98	65	-	84	54	-	78	50	-	63	36	-	63	32	-
24	97	67	-	98	64	-	84	56	-	79	46	-	62	36	-	61	36	-
25	102	65	-	101	63	-	81	57	-	77	45	-	63	45	-	54	41	-
26	101	64	-	101	63	-	82	53	-	76	46	-	58	43	0.02	55	32	-
27	102	66	-	97	63	-	81	55	-	78	45	-	61	36	-	61	39	-
28	103	65	-	95	63	-	80	56	-	65	45	-	62	42	-	57	37	0.20
29	95	67	-	101	64	-	76	47	-	81	46	-	61	45	-	54	45	0.40
30	105	64	-	99	61	-	77	45	-	81	56	-	64	45	-	54	37	-
31	104	68	-	101	65	-	-	-	-	81	54	-	-	-	-	57	34	-

TABLE 1

MONTHLY WEATHER REPORTS

HAIFA - REFINERY SITE

DATA SUPPLIED BY C.R.L. HAIFA REPORTED BY W.P. BELL

	1 9 4 [illegible]			1 9 4 5			1 9 4 4		
	Temperatures°F		Humidity	Temperatures°F		Humidity	Temperatures°F		Humidity
	Dry Bulb	Wet Bulb	%	Dry Bulb	Wet Bulb	%	Dry Bulb	Wet Bulb	%
January				59	57.5	89	60	56	79
February	62	54.5	63	60	58	87	62	55	65
March	65.5	56	68	61	59.5	92.5	67	60	68
April	73	63.5	56	65	64	93	72	(66)	(73)
May	80	69	58	75	68	70	76	(70)	(73)
June	87	74	53	84	75	68	82	(73)	(72)
July	89	74	52	85	76	68	86	(79)	(72)
August	87	74	55	88	78	64.5	82	73	66
September	86	75.5	65	87.5	77	63			
October	84	71.5	56	86	74.5	59			
November	79	69	59	77	68	63			
December	57	53	80	70	64	72			

Remarks:- (1) Figures in brackets are probably too high.
(2) Omitted figures were not registered at the time
(3) This table omitted in Summarised Data on Nami
Absolute or Extreme Values not given.

YES/HNA.

Year & Month	Press. @ noon	Temperature °F										Relative Humidity %			Rainfall		
	Mean (inches)	Average Dry Bulb Temp.			Extreme Dry Bulb Temp.				Average Wet Bulb Temp.							Highest in 24 hours	
		Day	Night	Mean	Max.	Date	Min.	Date	Day	Night	Mean	Day	Night	Mean	Total	Inches	Date
1946 CONTINUED																	
July	29.77	86	77	81.5	97	24:7	65	19:7	77	73	75	66	83	75	NIL	-	-
August	29.76	87.5	78	83	96	15:8	69	9:8	78	74	76	66	83	74	NIL	-	-
September	29.85	86	77.5	82	94.5	10:9	67	30:9	75.5	72.5	74	62	79	70	NIL	-	-
October	29.98	80	69.5	75	98.5	24:10	55	31:10	68.5	63.5	66	57	73	65	0.396	0.190	14:10
November	30.06	76.5	64	70	93	18:11	54	14:11	65.5	59.5	62.5	57	78	67	trace	trace	29-11
December	30.05	63	59	61	77	7:12	47	21:12	56.5	53.5	55	68	70	69	4.335	1.342	14:12
1947 January	29.98	59	54	56.5	76	27:1	42	14:1	54	51.5	53	72	85	79	10.556	2.890	13:1
February	30.02	63	55	59	81	28:2	44	10:2	57	53	55	70	90	80	1.405	0.463	17:2
March	30.04	70	58	64	93	27:3	46	16:3	62	55	58.5	66	85	75	0.460	0.232	5:3
April	30.03	74	63	68.5	99	12:4	47	17:4	63.5	58	61	58	75	66	0.603	0.256	16:4
May	29.98	80	69	74.5	98	4:5	57	15:5	69	63	66	58	72	65	0.210	0.116	12:5
June	29.90	84	73	78.5	96	28:6	62	22:6	72	68	70	57	77	67	NIL	-	-
July	29.78	87	77	82	99	21:7	68	21:7	76	73	74.5	61	83	72	NIL	-	-
August	29.84	88	77	82.5	96	2:8	71	8:8	78	74	76	64	85	75	NIL	-	-

Remarks:- Omitted figures were not registered at the time.

WPB/HNA.

TABLE III

PALESTINE METEOROLOGICAL SERVICE

MONTHLY WEATHER REPORTS

HAIFA MT. CARMEL

SUPPLIED BY PALESTINE GOVERNMENT

Year & Month	Pressure x) Mean Inches	TEMPERATURE °F G.M.T. 06	12	18	MEAN Max.	Min.	Mean	EXTREME Max.	Date	Min.	Date	Relative Humidity (%) G.M.T. 06	12	18	Mean	Rainfall Total Inches	Highest in 24 Hours Inches	Date
1946 December	29.94	55	63	58	64	52	58	72	2:12	46	22:12	69	59	69	66	4.095	1.350	14:12
1947 January	29.90	52	56	54	59	50	54.5	68	27:1	44.5	14:1	77	74	75	55	11.949	3.185	13:1
February	29.96	55	61	56	63	50	56.5	75.5	28:2	43	4:2	69	68	76	71	1.145	0.362	17:2
March	29.97	60.5	66	60	69	56	62.5	87	27:3	50.5	16:3	69	60	75	68	0.386	0.200	17:3
April	29.96	65	69	63	72	60	66	92	11:4	49	17:4	62	60	69	64	0.524	0.240	16:4
May	29.86	71.5	75	68.5	79	64.5	71.5	93	4:5	59	13:5	61	57	72	63	0.240	0.086	9:5
June	29.85	73.5	77	71	79.5	68	74	84	28:6	64	2:6	74	69	85	76	-	-	-

x) Corrected to sea level.

WPB/HNA

(5) [illegible]

Precipitation

Mean Annual Rainfall

Station	Height in Feet (approx.)	Inches of rainfall	Period	Authority
Lower Delta				
Fao	7	6.6	1936-9	Port
Maqil	7	5.2	1928-39	Railways
Shuaiba	60	5.7	1925-39	R.A.F.
Ghubaishiye	13	3.2	1928-39	Railways
Ur	23	2.9	"	"
Amara	30	8.3	1936-9	Posts and Telegraphs
Upper Delta				
Samawa	90	3.0	1928-39	Railways
Diwaniya	70	4.9	"	R.A.F.
Hilla	90	5.9	"	Railways
Karbala	85	2.4	"	"
Hindiya	112	3.8	"	Irrigation
Habbaniya	144	5.8	1937-9	R.A.F.
Qala Sikar	43	4.2	1936-9	Posts and Telegraphs
Kut al Imara	62	5.9	"	"
Hinaidi (Baghdad)	110	5.5	1928-39	R.A.F.
Samarra	223	3.9	"	Railways
Mandali	350	14.4	1936-9	Posts and Telegraphs
Jazira and Euphrates above Ramadi				
Baiji	469	8.5	1934-9	I.P.C.
Sinjar	1,950	19.5	1936-9	Posts and Telegraphs
Bir Ugla	1,280	17.2	1936-8	Police
Haditha	450	5.6	1934-9	I.P.C.
Ana	500	5.4	1936-9	Posts and Telegraphs
Assyrian Plains and Foothills				
Table Mt. (Mansur)	220	6.7	1928-39	Railways
Qaraghan (Jalowla)	330	7.3	"	"
Khanaqin	660	12.0	1931-9	"
Tus Khurmatli	720	8.3	1928-39	"
Iftikhar	670	8.6	"	"
Kirkuk	1,000	14.8	"	I.P.C. and Railways
Ditis	780	17.2	1936-9	I.P.C.
Erbil	1,360	18.2	1936-8	Posts and Telegraphs
Mosul	730	13.0	1925-39	R.A.F.
Kurdish Mountains				
Halabja	2,300	43.3	1936-9	Posts and Telegraphs
Sulaimaniya	2,750	32.9	"	"
Diana (Rowandiz)	2,700	31.4	1936-7, 1939	"
Agra	2,500	36.9	1936-9	"
Amadia	3,500	43.2	"	"
Zakho	1,450	40.4	"	"
Western and Southern Desert				
T1	1,040	6.6	1934-9	I.P.C.
H1	1,340	5.9	"	"
H2	1,930	5.7	"	"
H5	2,550	4.8	"	"
Rutba	2,020	5.8	1929-39	R.A.F.
Nukhaib	1,000	3.7	1936-9	Police
Shabicha	860	4.3	"	"
Salman	660	4.2	"	"
Busaiya	470	4.4	"	"

Precipitation

Rainfall in Inches and Number of Rain-days

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year	Max. in 24hrs.
SHUAIBA (13-14 years' observations)														
Inches	1.3	1.2	0.4	0.5	0.1	0.0	0.0	0.0	0.0	0.1	1.1	1.0	5.7	2.2
Days	6.5	0.5	2.9	2.4	0.5	0.0	0.0	0.0	0.0	0.8	4.0	3.7	21.3	-
DIWANIYA (10-12 years' observations)														
Inches	1.0	0.9	0.2	0.5	0.7	0.0	0.0	0.0	0.0	0.0	0.6	0.9	4.9	4.5 ≈
Days	..	..	..	..	Not known			..	..	..	..	..	..	..
HINAIDI (13-14 years' observations)														
Inches	1.2	1.1	0.3	0.4	0.4	0.0	0.0	0.0	0.0	0.1	1.0	1.0	5.5	1.5
Days	4.9	5.5	2.6	2.7	1.8	0.2	0.0	0.0	0.1	1.5	4.5	4.5	28.3	-
RUTBA (9-10 years' observations)														
Inches	0.9	0.7	0.1	0.4	0.2	0.0	0.0	0.0	0.0	0.1	0.7	0.7	3.8	1.8
Days	4.3	3.0	1.0	3.0	1.7	0.0	0.0	0.0	0.3	1.0	3.7	3.5	20.5	-
MOSUL (13-14 years' observations)														
Inches	2.1	3.0	1.6	1.8	0.5	0.0	0.0	0.0	0.0	0.2	1.8	2.0	13.0	3.4 ≠
Days	8.8	14.3	6.8	7.4	3.1	0.7	0.2	0.0	0.1	1.6	7.8	9.1	59.9	-

In the rainfall, the figure 0.0 indicates a mean rainfall of less than 0.05; in the rain-days the figure 0.0 indicates a total of less than 5 days in the month over a period of 100 years, i.e. less than 1 rain-day in 20 years.

≈ Abnormal thunderstorm in May.

≠ Abnormal downpour in November.

IRAQ.

5b.

SYRIA & LEBANON.

Precipitation

Rainfall (inches)

	Yrs. obsns.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Coast														
Alexandretta	10-11	3.0	3.5	2.5	2.2	1.8	1.5	0.5	0.6	2.0	2.9	2.9	3.9	27.3
Beirut	61	7.3	6.4	3.5	2.2	0.6	0.1	0.0	0.0	0.2	1.9	5.1	7.5	34.8
Haifa	14	7.1	5.7	0.9	0.7	0.1	0.0	0.0	0.0	0.0	0.5	2.7	6.7	24.4
Mountains														
El Kareya	10	11.1	13.7	7.7	5.7	1.4	0.3	0.0	0.0	0.3	2.0	6.5	10.0	56.7
Depression														
Homs	6-10	2.9	3.3	1.0	1.0	0.2	0.0	0.0	0.0	0.04	1.0	1.8	2.0	13.4
Ksara	8-11	5.6	6.0	2.3	2.5	0.3	0.0	0.1	0.0	0.1	1.1	2.2	4.5	24.7
Steppe and Desert														
Aleppo	5-7	3.0	2.8	1.0	1.3	0.4	0.1	0.0	0.1	0.0	0.8	2.4	3.2	15.1
Selemiyeh	2?	2.4	3.5	1.6	1.2	0.8	0.2	0.0	0.0	0.0	0.4	0.5	2.2	12.8
Damascus	7-10	1.7	2.1	0.4	0.5	0.2	0.0	0.0	0.0	0.7	0.4	1.6	1.6	9.2
Palmyra	6-9	1.0	0.8	0.2	0.5	0.3	0.0	0.0	0.0	0.0	0.3	0.3	1.1	4.5
Deir ez Zor	5-10	1.6	1.0	0.3	0.6	0.1	0.0	0.0	0.0	0.0	0.2	1.5	1.0	6.3
Urfa	10	2.6	3.0	2.6	1.3	1.4	0.0	0.0	0.0	0.0	0.4	1.9	2.9	16.1

SYRIA & LEBANON

Mean Number of Rain-days *

	Stns.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
[illegible]	9	9	12	8	7	5	4	2	2	5	6	8	9	76
[illegible]	61	15	14	11	6	3	1	1	1	1	4	9	13	78
[illegible]	14	14	13	5	4	1	0	0	0	0	2	6	11	56
[illegible]	10	15	12	14	7	5	2	0.2	0	1	6	10	12	84
Mediterranean														
Coast	2-7	9	11	9	5	0.7	0.1	0	0	0.1	2	4	9	50
Inland	8-11	14	12	9	6	3	0.7	0	0.1	0.9	3	8	11	68
Steppe and Desert														
[illegible]	5-9	11	11	7	4	2	0.5	0	0.2	0	3	7	11	56
[illegible]	29	12	15	8	5	3	1	0	0	0	2	4	10	60
[illegible]	7-8	7	7	2	3	0.7	0.1	0	0	2	2	3	5	33
Palmyra	5-8	6	4	3	3	1	0.3	0.3	0	0	3	4	6	31
[illegible]	5-8	6	5	3	3	0.9	0.4	0.0	0	0	2	4	5	29
[illegible]	7	8	9	11	9	6	1	0	0	1	3	8	9	65

* Rain-day is one with 0.008 inch rainfall or more.

Number of Days with Hail

	Stns.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
[illegible]	25	1.2	1.6	1.5	0.4	0.1	0.1	0.0	0.0	0.0	0.1	0.4	1.2	6.7
[illegible]	4	0.6	0.6	3.6	0.6	0.0	0.3	0.0	0.0	0.2	0.2	0.0	1.4	7.8

Sc. [illegible]

Precipitation (in inches)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1. Coast													
Acre(1928-38)													
Mean	5.5	7.9	0.9	0.7	0.2	trace	0.0	0.0	0.2	1.3	4.1	3.7	24.5
Max. in 24 hrs.	1.2	1.1	0.5	0.4	0.1	trace	0.0	0.0	0.1	0.3	0.9	1.4	-
Haifa(1921-34)													
Mean	7.1	5.7	0.9	0.7	0.1	0.0	0.0	0.0	0.0	0.5	2.7	6.7	24.4
Max. in 24 hrs.	3.4	2.2	1.0	1.0	0.4	0.2	0.3	0.1	0.1	1.9	2.6	7.2	-
Max. in month and year	12.1	10.5	6.0	3.5	2.1	0.6	0.0	<0.1	0.5	3.3	13.6	13.9	39.5
Min. in month and year	0.7	0.2	0.9	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	16.8
Jaffa(1902-12)													
Mean	5.6	3.9	2.7	0.9	0.1	<0.1	0.0	0.0	0.2	1.4	3.2	5.6	23.6
Max. in month and year	8.6	5.9	7.6	2.0	0.6	0.2	0.0	0.0	1.1	3.9	5.5	12.5	28.4
Min. in month and year	4.0	1.0	<0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.4	1.9	17.3
Gaza(1921-34)													
Mean	3.6	3.4	0.7	0.7	0.1	0.0	0.0	0.0	0.0	0.3	1.4	3.6	13.8
Max. in 24 hrs.	2.7	1.8	0.8	2.7	0.4	0.1	0.0	0.0	0.0	1.3	2.1	2.9	-
2. Inland													
Jenin(1921-34)													
Mean	5.1	5.4	1.1	1.2	0.1	0.0	0.0	0.0	0.0	0.3	1.7	4.1	19.0
Max. in 24 hrs.	2.2	2.6	1.1	2.5	0.5	0.1	0.0	0.1	0.0	1.1	2.0	2.1	-
Nazareth(1891-1907													
Mean	6.3	4.6	3.7	1.0	0.2	0.0	0.0	0.0	0.0	0.8	3.4	7.1	27.1
Max. in month and year	14.2	10.3	5.9	2.8	1.0	0.0	<0.1	0.0	<0.1	2.5	9.1	12.8	37.9
Min. in month and year	1.2	1.7	<0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.7	18.5

PALESTINE

Precipitation (in inches) (Cont'd)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Beit Jemal(1930-8)													
Mean	4.3	4.0	1.1	0.7	0.1	0.0	0.0	0.0	trace	0.6	2.8	2.5	16.1
Max. in 24 hrs.	1.2	1.5	0.[illegible]	0.5	0.1	0.0	0.0	0.0	trace	0.3	1.4	0.8	-
Jerusalem(1918-34)													
Mean	4.1	5.3	1.1	1.0	0.1	0.0	0.0	0.0	0.0	0.2	1.2	2.9	15.9
Max. in 24 hrs.	3.9	3.4	1.[illegible]	1.5	0.5	0.1	0.0	trace	0.4	0.9	2.2	3.0	-
≠ Max. in month and year	14.5	12.6	12.[illegible]	3.5	1.3	0.2	0.0	0.1	0.8	2.3	8.0	16.5	41.6
≠ Min. in month and year	0.1	0.2	0.[illegible]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.5	13.3
El Latrun(1901-12)													
Mean	6.5	3.3	2.[illegible]	1.3	0.3	<0.1	0.0	0.0	<0.1	0.9	2.4	5.2	22.8
≠ Max. in 24 hrs.	4.6	2.1	1.[illegible]	1.9	0.5	0.0	0.0	0.0	0.3	1.4	1.6	3.1	-
Max. in month and year	8.9	7.7	6.[illegible]	4.0	1.6	0.2	0.0	0.0	0.1	4.5	7.0	12.5	32.5
Min. in month and year	3.4	0.0	0.[illegible]	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	15.8
Hebron(1896-1914)													
Mean	6.2	4.6	3.4	2.0	0.3	<0.1	0.0	0.0	<0.1	0.5	2.1	5.1	24.3
Max. in month and year	13.9	12.4	8.[illegible]	8.3	2.2	1.3	0.0	0.0	0.2	2.5	6.1	14.1	39.8
Min. in month and year	1.6	0.2	0.2	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	13.3
Beersheba(1921-34)													
Mean	1.9	2.2	0.7	0.4	0.1	0.0	0.0	0.0	0.0	0.1	0.8	1.[illegible]	7.8
Max. in 24 hrs.	2.0	1.[illegible]	1.[illegible]	1.0	1.0	0.0	0.0	0.0	trace	0.4	1.4	2.5	-

Palestine

Precipitation (in inches) (Cont'd)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
3. Jordan Valley													
Tiberias(1890-1907)													
Mean	4.7	3.2	2.6	1.1	0.2	0.0	0.0	0.0	<0.1	0.6	2.9	5.1	20.2
// Max. in 24 hrs.	2.7	1.2	2.0	1.5	0.4	0.0	0.0	0.0	<0.1	0.5	1.6	2.4	-
Max. in month and year	11.2	6.5	5.0	3.0	0.9	0.0	0.0	0.0	<0.1	2.1	6.7	8.8	27.7
Min. in month and year	0.5	<0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	14.4
Beisan(1930-8)													
Mean	3.1	2.8	0.7	0.4	0.2	0.0	0.0	0.0	0.0	0.7	1.2	1.4	10.5
Max. in 24 hrs.	0.9	0.9	0.1	0.3	0.1	0.0	0.0	0.0	trace	0.5	0.4	0.6	-
Jericho(1921-34)													
Mean	1.3	1.3	0.2	0.4	0.1	0.0	0.0	0.0	0.0	0.1	0.4	1.2	5.0
Max. in 24 hrs.	1.0	1.3	0.6	0.7	1.0	0.2	0.1	0.0	trace	0.2	1.0	1.6	-
Dead Sea, North end(1934-7)													
Mean	0.6	0.4	<0.1	<0.1	<0.1	0.0	0.0	0.0	0.0	0.4	<0.1	0.4	1.9
Dead Sea, outh end(1935-6)													
Mean	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.4	1.2
4. Transjordan													
Amman(1924-41)													
// Mean	2.5	3.3	0.6	0.8	0.1	0.0	0.0	0.0	0.0	0.3	1.3	1.8	10.5
Max. in 24 hrs.	2.0	2.8	1.1	1.8	0.9	0.0	0.0	0.0	0.0	0.4	3.1	2.1	-

* (1884-1905)
δ (1907-32)
Δ (1880-96)
/ (1901-12)
// (1850-9)
/// 10 years' observ.

(6) GROUND TEMPERATURES AT ALTAID, IRAQ

SUPPLIED BY MIDDLE EAST PIPELINES, LONDON - D. BUCKHAM.

PERIOD DECEMBER 1946
TO NOVEMBER 1947.

STATISTICAL RESULTS

Temperature at 2 Hourly Intervals.

ALWAND REFINERY GROUND TEMPERATURE AT A DEPTH OF 4 FEET.

Time	00.	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	Hrs.
Average	77.3	76.8	76.7	76.7	77.9	78.1	78.6	78.8	78.8	78.3	77.7	77.5	°F
Min.	55	55	55	55	57	58	59	60	59	58	58	56	°F
Max.	99	99	93	93	96	97	97	96	96	95	95	99	°F

Yearly Characteristics.

Average 77.7°F.
Minimum 55 °F.
Maximum 97 °F.

The figure of 55°F for the minimum temperature is not considered reliable as it occurred in November 1947 and does not correspond with the daily temperature at the time. For this reason it seems probable that the minimum figure should be taken as 56°F which was registered on February 10th 1947. An error in the instrument has been confirmed from site. (Abadan memo 37075 of 26th January, 1948.)

ALWAND REFINERY SHADE TEMPERATURES.

Time	00.	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	Hrs.
Average	69.2	66.7	64.4	63.7	70.6	78.6	83.4	85.2	84.6	81.6	78.1	72.5	°F
Min.	35	34.2	32.5	31.5	30.5	39	44	45	47	48	41	34	°F
Max.	102	100	99	98	102	109	117	117	117	114	110	103	°F

Monthly Characteristics.

Average 74.9
Minimum 30.5
Maximum 117

SUPPLIED BY MIDDLE EAST PIPELINES [illegible]

STATISTICAL RESULTS

Temperature at 2 hourly intervals.

ALMAND REFINERY CRUDE TEMPERATURE AT A DEPTH OF 4 FEET.

Time	00.	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	22.00	Ave.
Avge.	63.7	63.3	63.3	63.3	64.1	64.9	65.4	65.7	[illegible]	[illegible]	[illegible]	[illegible]	°F
Min.	55	55	55	55	57	58	59	60	58	58	58	58	°F
Max.	69	69	69	69	70	71	72	71	71	70	70	70	°F

Daily Temperature Range

Average 2.96°F
Minimum 1 °F
Maximum 5 °F

Monthly Characteristics

Average 64.2°F
Minimum 55 °F (Recorded on [illegible])
Maximum 72 °F (1200 hrs 2nd Nov.)

ALMAND REFINERY - SHADE TEMPERATURE

Time	00.	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	22.00	Ave.
Avge.	61.1	59.4	57.1	56.1	60.3	67.0	72.8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	°F
Min.	51	50	49	47	51	56	59	59	[illegible]	[illegible]	[illegible]	[illegible]	°F
Max.	76	74	74	72	80	84	86	87	[illegible]	[illegible]	[illegible]	[illegible]	°F

Monthly Characteristics.

Average 64.9°F
Minimum 47 °F
Maximum 89 °F

OCTOBER 1947

[illegible] RESULTS

Temperature at 2 Hourly Intervals.

[illegible] TEMPERATURE AT A DEPTH OF 4 FEET

[illegible]	00..	0200	[illegible]	[illegible]	[illegible]	1000	1200	1400	1600	1800	2000	22.00	[illegible]
[illegible]	73.5	73.3	[illegible]	[illegible]	[illegible]	75.2	75.8	76.0	75.9	74.5	[illegible]	[illegible]	[illegible]
[illegible]	69	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	70	70	70	70	[illegible]	69	[illegible]
[illegible]	76	[illegible]	[illegible]	[illegible]	[illegible]	80	80	80	80	80	78	78	78	[illegible]

Daily Temperature Range.

Average [illegible]°F
Minimum [illegible]
Maximum [illegible]

Monthly Characteristics.

Average 74.3°F
Minimum 68.[illegible]°F ([illegible] [illegible] 78 [illegible])
Maximum 80 °F ([illegible] [illegible] 2 [illegible])

[illegible] TEMPERATURE

[illegible]	00..	0200	[illegible]	[illegible]	[illegible]	1000	1200	1400	1600	1800	2000	22.00	[illegible]
[illegible]	70.9	[illegible]	[illegible]	[illegible]	[illegible]	83.2	83.2	80.3	80.6	84.5	79.6	78.9	[illegible]
[illegible]	55	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	74	66	62	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible] Characteristics.

[illegible] 68.2
[illegible] [illegible] (0600 hrs 24 Oct.)
[illegible] [illegible] ([illegible] hrs [illegible] Oct)

SEPTEMBER 1947

STATISTICAL RESULTS

Temperature at 2 Hourly Intervals.

ALWAND REFINERY GROUND TEMPERATURE AT A DEPTH OF 4 FEET.

Time	00.	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	22.00	Hrs.
Avge.	83.8	83.7	83.4	83.1	85.4	86.2	86.4	86.7	86.7	85.7	84.5	84.1	°F
Min.	77	77	77	76	78	78	79	80	80	78	78	77	°F
Max.	88	88	88	87	90	90	90	91	91	90	90	88	°F

Daily Temperature Range.

Average 3.60°F
Minimum 2 °F
Maximum 5 °F

Monthly Characteristics.

Average 84.9°F
Minimum 76 °F (0600 hrs 28 Sept.)
Maximum 91 °F (1400 hrs 1 Sept.)

ALWAND REFINERY SHADE TEMPERATURE

Time	00.	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	22.00	Hrs.
Avge.	79.0	76.1	74.2	72.0	82.9	91.8	97.2	99.2	98.7	94.9	88.8	83.8	°F
Min.	74	72	68	64	75	87	90	92	91	86	80	76	°F
Max.	95	93	90	86	93	106	109	111	112	104	98	96	°F

Monthly Characteristics.

Average 86.5 °F
Minimum 64°F (0600 hrs 8 Sept.)
Maximum 112°F (1600 hrs 15 Sept.)

19/31 AUGUST 1947

STATISTICAL RESULTS

Temperature at 2 Hourly Intervals.

ALWARD REFINERY GROUND TEMPERATURE AT A DEPTH OF 4 FEET.

Time	00.	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	22.00	Hrs.
Avge.	90.5	90.1	90.0	90.0	93.3	93.6	94.0	94.3	95.9	93.2	92.3	91.2	°F
Min.	88	88	87	87	90	90	90	91	91	90	89	89	°F
Max.	93	93	93	93	95	95	95	95	95	95	95	94	°F

Daily Temperature Range.

Average 4.3°F
Minimum 2 °F
Maximum 7 °F

Monthly Characteristics.

Average 92.2°F
Minimum 87 °F (0400 hrs 30 Aug.)
Maximum 95 °F (0800 hrs 19 Aug.)

ALWARD REFINERY SHADE TEMPERATURE

Time	00.	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	22.00	Hrs.
Avge.	86.8	83.2	80.1	77.7	91.4	99.8	104.9	106.8	106.5	104.7	98.4	93.1	°F
Min.	80	76	72	70	82	92	101	103	103	100	92	87	°F
Max.	96	94	93	93	101	108	112	114	113	111	104	99	°F

Monthly Characteristics.

Average 94.4°F
Minimum 70 °F (0600 hrs 31 Aug.)
Maximum 114 °F (1400 hrs 26 Aug.)

JULY 1947

STATISTICAL RESULTS

Temperature at 2 Hourly Intervals.

ALWAND REFINERY GROUND TEMPERATURE AT A DEPTH OF 4 FEET.

Time	00..	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	22.00	Hrs.
[illegible]	91.0	90.6	90.5	90.8	93.7	94.0	94.0	94.1	94.3	94.0	92.6	91.9	°F
[illegible]	85	85	86	87	92	92	92	92	92	92	90	90	°F
[illegible]	95	95	93	93	96	97	97	96	96	95	95	95	°F

Daily Temperature Range.

Average 5.56°F
Minimum 3 °F
Maximum 9 °F

Monthly Characteristics.

Average 92.7°F
Minimum 85 °F (0000 hrs 31 July)
Maximum 97 °F (1000 hrs 25 July)

ALWAND REFINERY SHADE TEMPERATURE

Time	00..	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	22.00	Hrs.
[illegible]	97.4	87.7	82.1	83.6	95.0	102.6	108.9	110.6	110.4	108.5	100.4	97.4	°F
[illegible]	85	80	73	77	90	96	104	105	105	104	95	92	°F
[illegible]	102	100	99	98	102	109	117	117	117	114	107	101	°F

Monthly Characteristics.

Average 98.8°F
Minimum 73 °F (0400 hrs 4 July)
Maximum 117 °F (1200 hrs 20 July)

JUNE 1947

STATISTICAL RESULTS

Temperature at 2 Hourly Intervals.

ALWAND REFINERY GROUND TEMPERATURE AT A DEPTH OF 4 FEET.

June	00.	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	22.00 Hrs.
Avge.	85.7	85.3	85.0	85.6	87.5	87.9	88.1	88.5	88.5	87.6	86.3	85.9 °F
Min.	87	86	86	87	89	89	89	90	90	88	87	87 °F
Max.	92	91	90	91	93	94	94	94	95	94	92	92 °F

Diurnal Temperature Range.

Daily 3.58°F
Minimum 3 °F
Maximum 5 °F

Monthly Characteristics.

Average 86.8°F
Minimum 86 °F (0400 hrs 17 June)
Maximum 95 °F (1600 hrs 16 June)

ALWAND REFINERY SHADE TEMPERATURE

June	00.	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	22.00 Hrs.
Avge.	85.6	82.2	79.4	79.6	93.4	99.7	102.5	104.6	104.7	102.8	96.7	90.5 °F
Min.	80	77	70	70	86	88	90	93	97	94	88	82 °F
Max.	91	88	87	90	100	106	110	114	114	110	104	97 °F

Monthly Characteristics.

Average 93.4°F
Minimum 70 °F (0400 hrs 5 June)
Maximum 114 °F (1400 hrs 28 June)

MAY 1947

STATISTICAL RESULTS

Temperature at 2 Hourly Intervals.

ALWAND REFINERY GROUND TEMPERATURE AT A DEPTH OF 4 FEET.

ime	00.	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	22.00	Hrs.
vge.	83.9	83.1	83.1	83.0	83.3	83.8	84.9	85.0	84.9	84.6	83.8	83.4	°F
in.	79.5	79	73	74.5	77.0	79.0	79.5	79.5	79.5	79.5	79.5	79.5	°F
ax.	88	88	88	88	88	88	90	90	90	90	88	88	°F

Daily Temperature Range.

Average 2.1°F
Minimum 1.0°F
Maximum 7.5°F

Monthly Characteristics.

Average 83.9 °F
Minimum 73 °F
Maximum 90 °F

ALWAND REFINERY SHADE TEMPERATURE

ime	00.	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	22.00	Hrs.
vge.	79.5	75.7	73.5	72.7	84.0	89.8	92.9	94.9	94.7	93.1	87.9	83.6	°F
in.	61	60	59	56	62	62.5	68	72	74	74	69	67.5	°F
ax.	92	87	84	90	94	104	105	104	104	103	98	98	°F

Monthly Characteristics.

Average 85.1°F
Minimum 56 °F (0600 hrs 16 May)
Maximum 105 °F (1200 hrs 30 May)

APRIL 1947.

STATISTICAL RESULTS

Temperature at 2 Hourly Intervals.

ALWAND REFINERY GROUND TEMPERATURE AT A DEPTH OF 4 FEET.

	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	22.00	Hrs.
	76.2	76.1	76.3	76.5	76.5	76.6	76.7	76.7	76.6	76.3	76.0	75.8	°F
	72	72	71	72	70	70.5	71.5	71.5	71.5	71.5	71.5	72	°F
	79	79	79.5	79.5	79	80	80	80	79.5	79.5	79	79	°F

Daily Temperature Range

Average 1.90F
Maximum 5°F
Minimum 3.5°F

Monthly Characteristics.

Average 76.3°F
Minimum 70 °F (0800 hrs 3 Apl)
Maximum 80 °F (1200 hrs 23 Apl)

ALWAND REFINERY SHADE TEMPERATURE

	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	22.00	Hrs.
	60.3	61.1	61.6	62.1	73.7	81.3	85.1	86.1	85.0	82.8	76.3	70.5	°F
	54	52	50	50	52	64	69.5	70	71	70	65	60	°F
	86	88	86	84	86	97	98.5	99	96	94	92	86.5	°F

Monthly Characteristics.

Average 74.60F
Minimum 50 °F (0400 hrs 18 Apl)
Maximum 99 °F (1400 hrs 26 Apl)

MARCH 1947

STATISTICAL RESULTS

Temperature at 2 Hourly Intervals.

ALWAND REFINERY GROUND TEMPERATURE AT A DEPTH OF 4 FEET

Time	00.	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	22.00 Hrs
Avge.	69.0	68.8	68.7	68.6	69.0	69.2	69.3	69.6	69.4	69.3	69.1	69.0 °F
Min.	66.5	66	66	66	66.5	66.5	67	67	67.5	67.5	67	67 °F
Max.	72	72	71.5	71.5	71	72	72	72	71.5	71.5	71.5	71.5 °F

Daily Temperature Range.

Average 1.8°F
Minimum 0.5°F
Maximum 5.0°F

Monthly Characteristics.

Average 69°F
Minimum 66°F (0200 hrs 1 March)
Maximum 72°F (1000 hrs 19 March)

ALWAND REFINERY SHADE TEMPERATURE

Time	00.	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	22.00 Hrs
Avge	59.3	57.8	56.4	55.1	60.5	68.0	73.4	75.0	72.3	69.2	63.0	61.5 °F
Min.	52	50	48	46	50	55	60.5	59	58	58	57	55 °F
Max.	72	73.5	74	74	70	80	86	86	85	84	76	73 °F

Monthly Characteristics.

Average 63.9°F
Minimum 46 °F (0600 hrs 3 March)
Maximum 86 °F (1200 hrs 22 March)

FEBRUARY 1947.

STATISTICAL RESULTS

Temperature at 2 Hourly Intervals.

ALHAND REFINERY GROUND TEMPERATURE AT A DEPTH OF 4 METT

Time	00.	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	22.00	Hrs.
Avge.	65.7	66.5	66.5	66.5	66.6	66.8	67.0	67.2	67.4	67.4	67.0	66.9	°F
Min.	66	66	66	66	66	66	66.5	66.5	66.5	66	66	66	°F
Max.	68	67.5	67.5	67.5	67.5	68	68	68	68.5	68	68	68.5	°F

Daily Temperature Range.

Average 1.2°F
Minimum .5°F
Maximum 2.0°F

Monthly Characteristics.

Average 66.8°F
Minimum 66 °F (0000 hrs 10 Feb)
Maximum 68.5°F (1600 hrs 2 Feb)

ALHAND SHADE TEMPERATURE

Time	00.	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	22.00	Hrs.
Avge.	49.2	47.6	46.3	44.6	47.6	53.4	58.8	61.8	61.8	58.1	54.1	51.7	°F
Min.	39	36	34	32.5	34	40	44	45	47	43	41	40	°F
Max.	60	57	57	55	55	63	69.5	72.5	74	70	63	63.5	°F

Monthly Characteristics

Average 48.8°F
Minimum 32.5°F (0600 hrs 5 Feb)
Maximum 74 °F (1600 hrs 15 Feb)

JANUARY 1947

STATISTICAL RESULTS

Temperature at 2 Hourly Intervals.

ALWARD REFINERY GROUND TEMPERATURE AT A DEPTH OF 4 FEET

Time	0000	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	Hrs
Average	69.0	68.9	68.8	68.6	68.4	68.7	68.9	69.2	69.5	69.4	69.3	69.1	°F
Min.	67	67	67	67	67	68	67.5	68	68	68	67.5	67	°F
Max.	72	71.5	70.5	70	70	71	71.5	71	72	72	72	71.5	°F

Daily Temperature Range.

Average 2.0°F
Minimum 1.0°F
Maximum 5.0°F

Monthly Characteristics.

Average 68.9°F
Minimum 67 °F (0800 hrs 4 Jan.)
Maximum 72 °F (1600 hrs 4 Jan.)

ALWARD REFINERY SPADE TEMPERATURE

Time	0000	0200	0400	0600	0800	2000	1200	1400	1600	1800	2000	2200	Hrs
Average	51.7	51.1	50.1	50.2	51.1	55.1	58.8	60.6	60.1	57.3	54.5	52.2	°F
Min.	43	43	40	36	36	43	50	53	52	49	44	44	°F
Max.	59	59.5	59	62	66	64	68	69	68	64	66	60	°F

Monthly Characteristics

Average 54.1°F
Minimum 36 °F (0600 hrs 26 Jan.)
Maximum 69 °F (1400 hrs 13 Jan.)

17/31 DECEMBER 1946

STATISTICAL RESULTS

Temperature at 2 Hourly Intervals.

ALWAND REFINERY GROUND TEMPERATURE AT A DEPTH OF 4 FEET.

ime	00.	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	22.00	Hrs.
ge.	72.9	73.0	72.8	72.6	72.5	72.5	72.5	73.0	73.4	73.6	73.4	73.2	°F
n.	71	70.5	70.5	70.0	70	69.8	69	69	72	71.5	71.5	71.0	°F
x.	76	77	76.5	76	75	75	75	76	76	77	77	77	°F

Diurnal Temperature Range.

Average 2.2°F
Minimum 1.0°F
Maximum 4.0°F

Monthly Characteristics.

Average 72.9°F
Minimum 69 °F (1200 hrs 31 Dec.)
Maximum 77 °F (0200 hrs 18 Dec.)

ALWAND REFINERY SHADE TEMPERATURE

me	00.	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	22.00	Hrs.
ge.	48.0	46.2	45.1	44.6	44.6	51.2	58.3	60.8	58.2	54.6	51.2	48.9	°F
n.	35.0	34.2	32.5	31.5	30.6	39.0	49.0	53.0	50.0	47.2	42.0	40.0	°F
x.	59.0	59.0	58.0	57.8	58.0	64.0	74.0	71.0	70.0	62.0	59.0	58.0	°F

Monthly Characteristics.

Average 50.9°F
Minimum 30.6°F (0800 hrs 27 Dec.)
Maximum 74.0°F (1200 hrs 30 Dec.)

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NOVEMBER 1947

STATISTICAL RESULTS

Temperatures at 2 Hourly Intervals.

ABADAN ELECTRIC CRUDE TEMPERATURES

(SURFACE LINE SYSTEM)

	0000	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	Hrs.
	[illegible]	58.5	58	56.5	58.2	69	80.2	80.4	84	76.6	70.2	65.4	°F
	50	49	46	46	48	52	53	59	62	56	56	52	°F
	72	72	73	73	73	95	112	116	104	100	89	81	°F

Daily Temperature Range.

Average [illegible]°F
Minimum [illegible]°F
Maximum 36 °F

Hourly Characteristics.

Average 68.6°F
Minimum [illegible]°F
Maximum 116 °F

ABADAN CRUDE TEMPERATURES

	0000	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	Hrs.
	67.5	65.7	64.4	62.8	64.6	72.5	76.5	80.2	80.4	75.2	71.5	69	°F
	58	57	54	52	54	55	60	64	65	64.5	63	60	°F
	71.5	68	70	80	64	80	93	95	95	87	83.5	88	°F

Hourly Characteristics.

Average [illegible]°F
Minimum [illegible]°F
Maximum [illegible]°F

OCTOBER 1947

STATISTICAL RESULTS

Temperature at 2 Hourly Intervals.

ABADAN INCOMING CRUDE TEMPERATURES

(SURFACE LINE SYSTEM)

Time	00.	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	22.00	Hrs.
Avge.	77.7	73.1	69.6	67.0	68.8	86.1	102.5	111.4	112.8	103.8	92.0	83.7	°F
Min.	67	62	58	56	58	59	74	88	100	90	80	73	°F
Max.	86	82	76	73	83	106	115	125	128	126	110	96	°F

Daily Temperature Range.

Average 46.1°F
Minimum 34 °F October 24th
Maximum 57 °F October 3rd

Monthly Characteristics.

Average 87.4°F
Minimum 56 °F
Maximum 128 °F

ABADAN SHADE TEMPERATURES

Time	00.	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	22.00	Hrs.
Avge.	77.3	75.5	74.3	72.2	76.0	89.2	97.8	100.6	99.4	91.9	84.3	80.1	°F
Min.	69	66	64.5	63	66	76	82	90	87	79	76	72	°F
Max.	85	83	82	81.5	88	102	109	112	112	105	94	88	°F

Monthly Characteristics

Average 84.8°F
Minimum 63 °F
Maximum 112 °F (1400 hrs 4 Oct.)

SEPTEMBER 1947

STATISTICAL RESULTS

Temperature at 2 Hourly Intervals.

ABADAN INCOMING CRUDE TEMPERATURES

(SURFACE LINE SYSTEM)

Time	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	Hrs.
Avge.	78.9	76.0	73.0	78.7	98.3	113.6	120.6	120.4	110.2	97.6	89.0	83.2	°F
Min.	74	71	68	71	90	107	115	111	100	90	81	80	°F
Max.	84	82	82	87	108	123	131	131	120	106	97	88	°F

Daily Temperature Range.

Average 47.6°F
Minimum 39 °F
Maximum 54 °F

Monthly Characteristics.

Average 94.95°F
Minimum 68 °F
Maximum 131 °F

ABADAN SHADE TEMPERATURES

Time	00.	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	22.00	Hrs.
Avge.	85.7	83.1	80.7	78.3	82.8	95.4	103.5	106.2	106.0	100.6	91.5	87.5	°F
Min.	78	76	73.5	71	74	89	97	99	99	94	86	82	°F
Max.	93	90	89	86	90	104	114	115	115	108	97	94	°F

Monthly Characteristics

Average 91.7°F
Minimum 71 °F (0600 hrs 21 Sept.)
Maximum 115 °F (1400 hrs 13 Sept.)

AUGUST 1947

STATISTICAL RESULTS

Temperature at 2 Hourly Intervals.

ABADAN HOURLY CRUDE TEMPERATURES

(SURFACE LINE SYSTEM)

	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	24.00 Hrs.
	87.2	82.4	81.0	87.4	105.5	121.2	128.5	128.6	120.4	103.0	98.0	92.0 °F
	85	79	75	81	97	116	124	122	112	100	91	84 °F
	93	89	87	103	119	127	136	139	136	120	108	97 °F

Daily Temperature Range

Average 68.4°F
Minimum 59 °F
Maximum 58 °F

Monthly Characteristics

Average 102.6°F
Minimum 75 °F (0600 hrs 4 Aug.)
Maximum 139 °F (1600 hrs 29 Aug.)

ABADAN SHADE TEMPERATURE

	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	22.00 Hrs.
	92.8	88.1	87.0	92.5	103.5	110.4	112.4	112.2	107.4	99.8	95.8 °F
	88	84	82	86	96	106	109	109.5	98	94	90.5 °F
	99	98	96	98	101	110	116	117	117.5	113	103	101.5 °F

Monthly Characteristics

Average 99.5°F
Minimum 82 °F (0600 hrs 16 Aug.)
Maximum 117.5°F (1600 hrs 29 Aug.)

STATISTICAL RESULTS

JULY 1947

Temperature at 2 Hourly intervals.

ABADAN WORKING GROUNDS TEMPERATURES

(SURFACE WIND SYSTEM)

	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	2400	
	93.2	87.3	84.0	90.6	100.5	126.3	132.8	136.0	126.6	112.0	102.6	96.5	°F
	34	33	29	32	38	52	52	58	55	36	36	33	°C
	99	97	93	99	101	130	142	147	141	128	116	104	°F

Daily Temperature Range

Average 50.9°F
Minimum 39 °F
Maximum 63 °F

Monthly Characteristics

Average 107.5°F
Minimum 78 °F
Maximum 147 °F

ABADAN SHADE TEMPERATURE

	0000	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	
	94.2	92.2	90.1	88.5	95.9	106.0	112.7	115.2	114.9	110.4	101.7	97.4	°F
	89.5	84	84	82	91	96	107	111	110	100	98	92	°F
	100	98	95	94	104	116	119	123	124	119	109	102	°F

Monthly Characteristics

Average 101.5°F
Minimum 82 °F (0600 12 July)
Maximum 124 °F (1600 and 3 July)

STATISTICAL RESULTS JUNE 1947

Temperature at 2 Hourly Intervals

ABADAN INCOMING CRUDE TEMPERATURES

(SURFACE LINE SYSTEM)

Time	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	2400	Hrs.
Avge.	86.5	82.8	79.4	88.8	107.7	122.9	130.4	130.9	124.1	109.8	98.2	91.8	°F
Min.	82	78	75	76	94	109	118	119	113	101	91	86	°F
Max.	95	89	84	99	115	130	142	145	143	131	114	105	°F

Diurnal Temperature Range

Average 52.3°F
Minimum 39 °F
Maximum 66 °F

Monthly Characteristics

Average 104.4°F
Minimum 75 °F (0600 Hrs. 6 June)
Maximum 145 °F (1600 Hrs. 28 June)

ABADAN SHADE TEMPERATURES

Time	0000	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	Hrs.
Avge.	91.1	89.1	86.4	84.8	94.9	106.2	111.2	112.6	111.9	107.8	98.4	93.9	°F
Min.	86	84	79	76	87	96	99	100	100	98	92	88.5	°F
Max.	97	94	92	92	103	114	119	120	121.5	117	105	99	°F

Monthly Characteristics

Average 99.0°F
Minimum 76.0°F (0600 hrs 6 June)
Maximum 121.5°F (1600 hrs 28 June)

MAY 1947

STATISTICAL RESULTS

Temperature at 2 Hourly Intervals.

ABADAN INCOMING CRUDE TEMPERATURES

(SURFACE LINE SYSTEM)

[illegible]	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	2400	Hrs
[illegible]	82.2	76.1	75.3	76.3	90.9	108.2	119.3	124.2	120.7	108.7	96.1	84.4	°F
[illegible]	68	65	62	63	72	90	101	101	100	90	84	75	°F
[illegible]	96	90	85	85	104	121	134	139	137	126	110	101	°F

[illegible] Temperature Range

[illegible] 49.6°F
[illegible] °F
[illegible] °F

Monthly Characteristics

Average 104.3°F
Minimum 62 °F (0600 hrs 1st May)
Maximum 139 °F (1600 hrs 27th May)

ABADAN SHADE TEMPERATURE

0000	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	Hrs.
87.2	81.3	79.5	78.2	87.2	96.3	101.3	103.5	102.6	99.2	91.4	86.6	°F
80	70	68	66	76	83	85	87	86	82	77	75	°F
96	92	90	88	100	110	114	118	115	113	103	97	°F

Monthly Characteristics

Average 90.8°F
Minimum 66 °F (0600 hrs 16 May)
[illegible] °F (1400 hrs 31 May)

APRIL 1947

STATISTICAL RESULTS

Temperature at 2 Hourly Intervals.

ABADAN INCOMING CRUDE TEMPERATURES

(SURFACE LINE SYSTEM)

[illegible]	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	2400	Hrs.
[illegible] 75.6	75.7	69.4	66.4	67.2	77.1	97.0	108.6	112.4	108.7	97.0	85.7	76.4	°F
[illegible]	58	56	55	55	64	78	92	93	87	85	72	68	°F
85	87	78	75	105	106	115	123	127	124	110	99	90	°F

Annual Temperature Range

Average 47.1°F
Minimum 28 °F
Maximum 60 °F

Monthly Characteristics

Average 85.7°F
Minimum 55 °F (0600 hrs 19 April)
Maximum 127 °F (1600 hrs 25 April)

ABADAN SHADE TEMPERATURES

[illegible]	0000	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	Hrs.
[illegible]ge.	75.1	72.0	69.9	68.0	74.8	85.4	91.4	93.6	93.4	89.8	82.8	78.8	°F
[illegible]in.	64	62	61.5	57	66	75	77	77	76	74	70	67	°F
[illegible]ax.	85	83	80	79	83	97	102.5	103.5	104	98	93	88	°F

Monthly Characteristics

Average 81.25°F
Minimum 57 °F (0600 hrs 23 April)
Maximum 104 °F (1600 hrs 25 April)

STATISTICAL RESULTS — MARCH 1947

Temperature at 2 Hourly intervals.

ABADAN INCOMING CRUDE TEMPERATURES

(SURFACE LINE SYSTEM)

Time	0000	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	Hrs.
Avge.	66.0	62.0	59.4	58.1	63.4	77.7	90.0	95.6	91.2	86.8	76.9	70.5	°F
Min.	60	56.0	54	51	49	57	70	65	66	67	65	63	°F
Max.	72	70	67	65	80	97	108	109	104	96	88	76	°F

Diurnal Temperature Range

Average 39.1°F
Minimum 5 °F
Maximum 48 °F

Monthly Characteristics

Average 74.7°F
Minimum 49 °F (0800 hrs 2 March)
Maximum 109 °F (1400 hrs 27 March)

ABADAN SHADE TEMPERATURES

Time	0000	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	Hrs.
Avge.	67.0	65.0	63.3	61.5	64.2	71.5	77.8	80.1	80.5	77.4	72.4	69.0	°F
Min.	61.5	59	56	54	54	62	73	68	69.5	70	66	65	°F
Max.	73.5	72	70	69	75	82	87	88	92	88	81	78	°F

Monthly Characteristics

Average 70.8°F
Minimum 54 °F (0800 hrs 2 March)
Maximum 92 °F (1600 hrs 28 March)

STATISTICAL RESULTS — FEBRUARY 1947

Temperature at 2 Hourly intervals

ABADAN INCOMING CRUDE TEMPERATURES

(SURFACE LINE SYSTEM)

[illegible]	0000	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	Hrs.
[illegible]	54.7	51.2	48.6	46.8	46.5	57.2	69.7	77.4	79.4	74.6	65.8	59.5	°F
[illegible]	46	43	39	37	36	42	56	57	57	55	56	52	°F
[illegible]	66	63	60	59	59	66	80	87	91	88	77	72	°F

Diurnal Temperature Range

Average 33.6°F
Minimum 5 °F
Maximum 50 °F

Monthly Characteristics

Average 60.95 F
Minimum 36 F (0800 hrs 7 Feb.)
Maximum 91 F (1600 hrs 17 Feb.)

ABADAN SHADE TEMPERATURES

[illegible]	0000	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	Hrs.
[illegible]	56.5	54.8	53.2	51.8	51.6	58.7	65.3	67.8	68.7	66.1	61.8	58.9	°F
[illegible]	49	48	46	44	43	50	56	58	58.5	57	55	51.5	°F
[illegible]	63	64	62	61.5	63	66	74	76	76	72	69	68	°F

Monthly Characteristics

Average 59.6°F
Minimum 43 °F (0800 hrs 7 Feb.)
Maximum 76 °F (1400 hrs 27 Feb.)

JANUARY 1947

STATISTICAL RESULTS

Temperature at 2 Hourly intervals

ABADAN INCOMING CRUDE TEMPERATURES

(SURFACE LINE SYSTEM)

Time	0000	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	Hrs.
Average	53.5	51.1	49.2	48.1	48.1	55.6	65.8	71.5	72.6	67.5	61.0	56.6	°F
Min.	44	42	40	39	40	47	56	60	60	59	50	46	°F
Max.	65	63	61	60	60	69	78	82	84	80	70	64	°F

Diurnal Temperature Range

Average 25.5°F
Minimum 5 °F
Maximum 43 °F

Monthly Characteristics

Average 58.3°F
Minimum 39 °F (0600 hrs 27 Jan.)
Maximum 84 °F (1600 hrs 12 Jan.)

ABADAN SHADE TEMPERATURES

Time	0000	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	Hrs.
Average	55.9	54.7	53.2	52.1	52.2	58.4	63.5	65.6	66.0	62.9	59.7	57.5	°F
Min.	50	48	46	46	46	51	56	57	60	58	52	51	°F
Max.	65	63	64	64	67	70	72	73	73	69	67	66	°F

Monthly Characteristics

Average 58.4°F
Minimum 46 °F (0400 hrs 18 Jan.)
Maximum 73 °F (1400 hrs 31 Jan.)

DECEMBER 1946

STATISTICAL RESULTS

Temperature at 2 hourly intervals

ABADAN INCOMING CRUDE TEMPERATURES

(SURFACE LINE SYSTEM)

	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	Hrs.
[illegible]	54.5	51.8	50.3	48.5	47.6	56.2	67.7	73.6	74.9	68.7	62.6	58.2	°F
[illegible]	[illegible]	39	35	34	33	43	55	63	65	60	52	47	°F
[illegible]	65	60	60	59	59	65	78	84	87	80	78	70	°F

Diurnal Temperature Range

Average 24.1°F
Minimum 14 °F
Maximum 39 °F

Monthly Characteristics

Average 59.5°F
Minimum 33 °F (0800 hrs 24 Dec.)
Maximum 87 °F (1600 hrs 1 Dec.)